Feasibility Report - Draft Environmental Impact Statement/Report
Water Resources Investigation

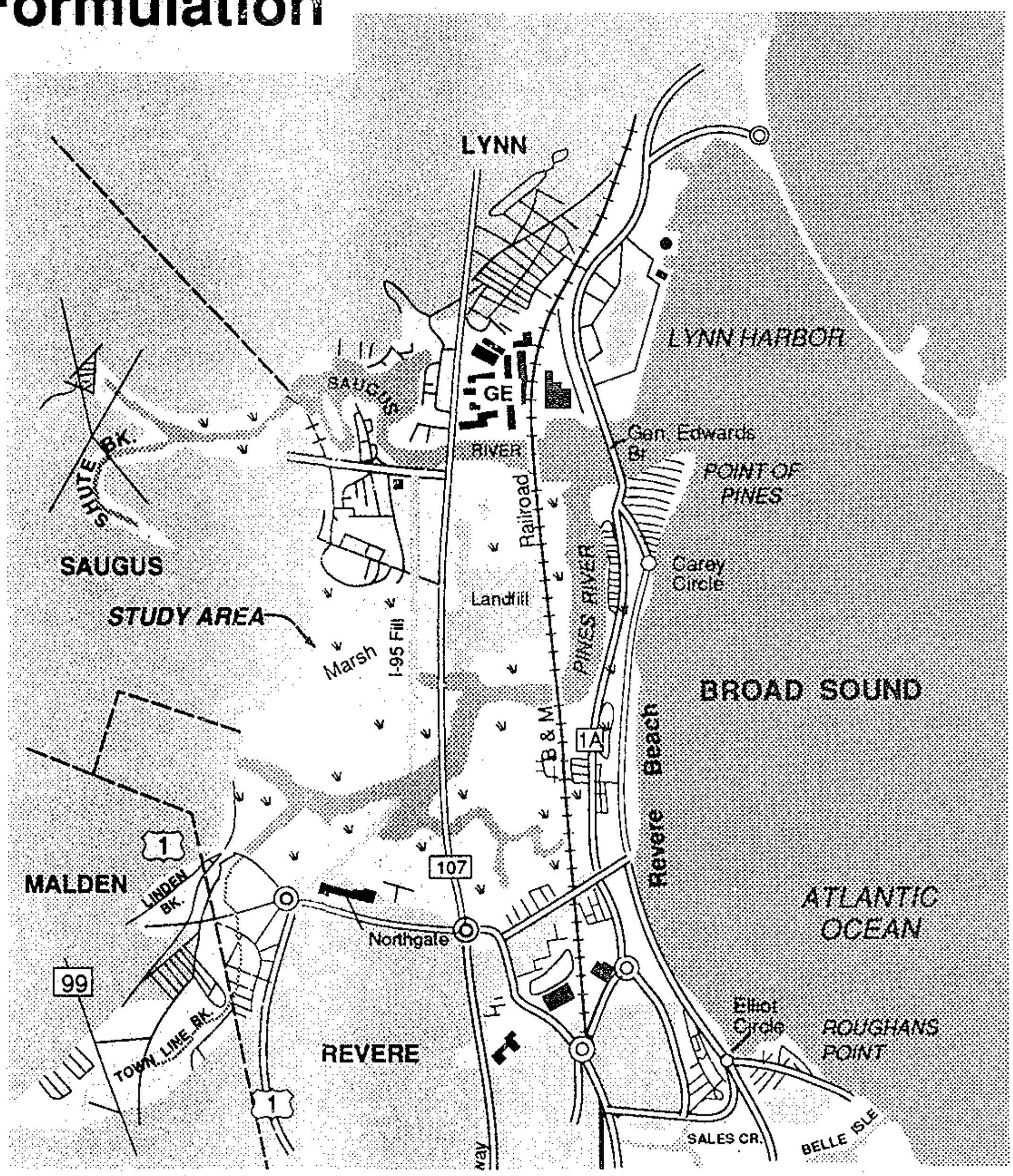
Saugus River and Tributaries, Lynn, Malden, Revere and Saugus, Massachusetts

Flood Damage Reduction

Volume 1

Appendix

A - Plan Formulation



US Army Corps of Engineers
New England Division

SAUGUS RIVER AND TRIBUTARIES FLOOD DAMAGE REDUCTION STUDY
Lynn, Malden, Revere and Saugus, Massachusetts/Summary of Study Reports:

Main Report and Environmental Impact Statement/Report (EIS/EIR): Summarizes the coastal flooding problems in the study area and alternative solutions; describes the selected plan and implementation responsibilities of the selected plan; and identifies environmental resources in the study area and potential impacts of alternative solutions, as required by the Federal (NEPA) and state (MEPA) environmental processes.

Plan Formulation (Appendix A): Provides detailed information on the coastal flooding problem and the alternatives investigated; includes: sensitivity analyses on floodgate selection (including location and size of gates and sea level rise); optimization of plans; comparison of alternative measures to reduce impacts; and public concerns.

Hydrology and Hydraulics (Appendix B): Includes descriptions of: the tidal hydrology and hydrology of interior runoff in the study area, and of wave runup and seawall overtopping, interior flood stage frequencies, tide levels, flushing, currents, and sea level rise effects without and with the selected project for various gated openings.

Water Quality (Appendix C): Includes descriptions of existing water quality conditions in the estuary and explores potential changes associated with the selected plan.

Design and Costs (Appendix D): Includes detailed descriptions, plans and profiles and design considerations of the selected plan; coastal analysis of the shorefront; detailed project costs; scope and costs of engineering and design; scope and costs of operation and maintenance; and design and construction schedules.

Geotechnical (Appendix E): Describes geotechnical and foundation conditions in the study area and the design of earth embankment structures in the selected plan.

Real Estate (Appendix F): Describes lands and damages, temporary and permanent easements and costs of the selected plan, including the five floodgate alignments studied.

Economics (Appendix G): Describes recurring and average annual damages and benefits in study area floodzones; economic analysis and optimization of alternative plans.

Socioeconomic (Appendix H): Describes the socioeconomic conditions in the study area and the affects of the selected plan on development in the floodplain and estuary.

Planning Correspondence (Appendix I): Includes all letters between community officials, agencies, organizations and the public and the Corps prior to agency and public review of the draft report.

Feasibility Study and EIS/EIR Comments and Responses (Appendix J): Includes all comments and Corps responses to letters received during agency and public review.

Environmental (Appendix K): Includes basic data from investigations of environmental resources in the study area and presents the Mitigation Incremental Analysis.

SAUGUS RIVER AND TRIBUTARIES

FLOOD DAMAGE REDUCTION STUDY

LYNN, MALDEN, REVERE AND
SAUGUS, MASSACHUSETTS

PLAN FORMULATION

APPENDIX A

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

June 1989

PLAN FORMULATION
APPENDIX A
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PROBLEM IDENTIFICATION

PLAN FORMULATION

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(fp) refers top "follows page"

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FIGURES

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Source: Revere Beach Reservation, Master Plan, Summary Report

IV. THE MASTER PLAN

e. Storm Drainage and Flooding Roadway and parkland flooding has continually been a problem at Revere Beach during heavy storms. The major flooding occurs at high tide when storm-driven waves overtop the seawall, flow across Revere Beach Boulevard, and down westerly slopes to the lower Ocean Avenue Basin.

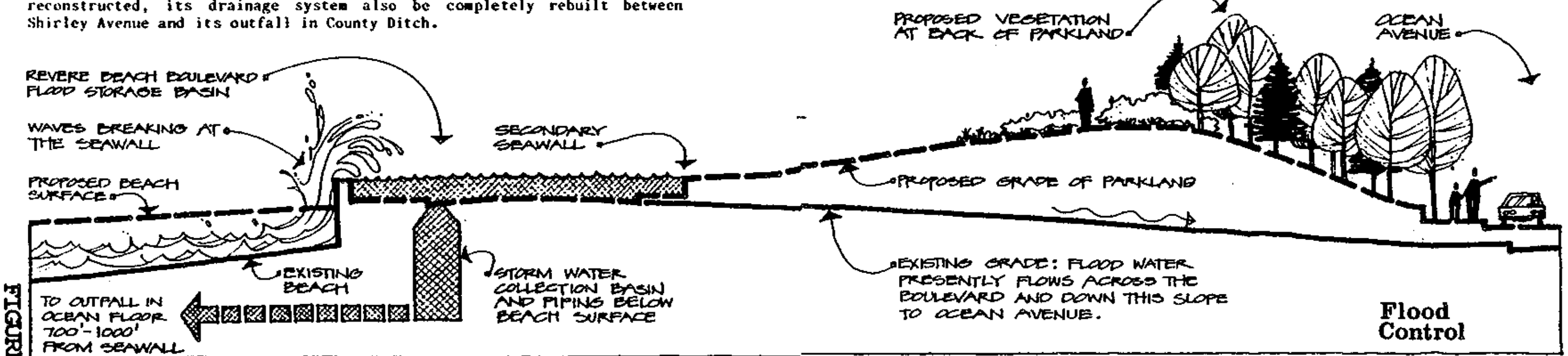
Studies have shown that adequate drainage facilities exist to remove heavy rainfall flood water, however, ocean wave overtopping is a more difficult problem since a very large volume of water is deposited west of the seawall in short of time. Existing drainage facilities are in very poor condition and cannot accommodate this sudden inundation.

The Master Plan recommends several steps to alleviate flooding conditions. Between Beach Street and Revere Street, overtopping flood waters will be contained on the Boulevard and drained eastward under the beach to an outlet in the floor of Broad Sound, 700 - 1000' from the seawall. A key component of this flood control system is the use of the Boulevard as a holding basin bounded by the seawall on the east, a 2' high granite sitting wall or "secondary seawall" on the western Boulevard edge, and high points in the Boulevard roadway preventing flow to the north or south. The parkland will also be mounded to provide increased protection for Ocean Avenue in the event of a hurricane or other severe storm. In addition to its obvious recreational value, resanding of the center section of the beach will serve to reinforce the flood control capability of the new Boulevard. Raising the level of the beach will force waves to break further to the east at high tide rather than at the seawall face, thus reducing the volume of overtopping water.

As major wave overtopping is contained on the Boulevard, the Ocean Avenue drainage system will be required to remove rainfall storm water only. However, due to the age and severely deteriorated condition of Ocean Avenue catch basins and piping, it is recommended that, as Ocean Avenue is reconstructed, its drainage system also be completely rebuilt between Shirley Avenue and its outfall in County Ditch.

Storm tide at the Bathhouse Pavilions, January 1978.

FIGURE 5



TYPICAL SECTION

Flood control concept. This section looking south shows Revere Beach Boulevard used as a flood storage basin. The Boulevard drainage system carries trapped flood waters eastward below the beach to an offshore outlet in the ocean floor. Constant operation of the system is ensured by the difference in elevation between the water surface on the Boulevard and the ocean surface.

- conducted water quality sampling, gaging and modeling of the currents in the estuary and rivers;

- conducted literature searches on the socioeconomics, environmental and cultural resource aspects of the project area;

- evaluated historical maps, past policies, legislation and plans of others to determine the most likely development in the study area for projecting future conditions;

- formulated numerous structural and nonstructural alternative plans, and developed costs and impacts to reduce overtopping and tidal flooding;

- evaluated the real estate and potential land costs of constructing these alternative plans;

- conducted about 100 meetings with the public to coordinate development, assessment and evaluation of these plans; and

- surveyed and evaluated the recreational potential of parkland at the Revere Beach Reservation.

TABLE 1

BUILDINGS ESTIMATED IN FLOODPLAINS

REVERE	100 YEAR	STANDARD PROJECT NORTHEASTER (SPN)
Revere Beach Backshore		
Residential	698	1170
Non-Residential	87	130
Point of Pines		
Residential	357	365
Non-Residential	3	5
Northgate		
Residential	50	100
Non-Residential	50	80
Town Line Brook		
Residential	180	720
Non-Residential	20	80
REVERE TOTAL		
Residential	1285	2355
Non-Residential	160	295
GRAND TOTAL - Revere	1445	2650
Lynn		
Residential	370	670
Non-Residential	420	570
	790	1240
Saugus		
East Saugus		
Residential	525	570
Non-Residential	25	30
	550	600
Upper Saugus River & Shute BK		
Residential	80	240
Non-Residential	20	60
	100	300
SAUGUS TOTAL		
Residential	605	810
Non-Residential	45	90
TOTAL	650	900
MALDEN - Linden BK		
Residential	188	205
Non-Residential	2	5
TOTAL	190	210
TOTAL STUDY AREA		
Residential	2448	4040
Non-Residential	627	960
GRAND TOTAL	3075 (Say 3100)	5000

HISTORICAL AND EXISTING CONDITIONS

The following sections include supporting information on the socioeconomic factors affected by flooding in the four communities surrounding the Saugus River Marsh.

SUMMARY OF WETLAND LOSSES

The following explains an investigation by the Corps Enforcement Unit on unauthorized work in the Saugus, Lynn and Revere marsh complex. The investigation included 24 sites identified in the IEP Socioeconomic Study of July 1988 and 17 sites identified prior to and during the July to December 1988 investigation by the Enforcement Unit. The IEP report, conducted for this investigation, is included in the Socioeconomic Appendix.

Before reporting the results of this investigation a few remarks to distinguish the limits of the Corps area of jurisdiction and the methods used by the Corps to evaluate the identified sites. Also, the methods used by IEP to identify areas where fill was deposited will help clarify the differences between the IEP and Corps estimates of fill placed in wetlands. The Corps and IEP investigations were conducted at different levels of detail. Briefly, in this investigation the Corps was attempting to document the discharge of fill material within or affecting "waters of the United States". Basically, this would include wetlands and areas within "tidal waters". To determine the status of a site, the Corps had access to extensive aerial photography from the 60's, 70's, 80's and a helicopter flyby, access to the Corps permit and enforcement files, ground visits to the sites and access to other federal employees who have worked in the area over the last 15 years.

According to the IEP "Preliminary assessment" study, 60 acres within the study area were filled between 1978 and 1987. IEP focused on changes in vegetation between 1978 and 1987 aerial photographs within wetlands, areas within tidal waters and in upland areas abutting the marsh. Causes of vegetative changes on the photographs were interpreted as fill. Ground checks were not employed or required to verify the interpretation of their data for this initial assesment. Fires, ecological succession or causes other than the discharge of fill material may have been responsible for the vegetative changes. Most of the upland sites, where they detected changes in vegetation, will probably be found to lie within the 100 year floodplain but are outside of the Corps area of jurisdiction.

Three areas in the estuary were not included in either the IEP or Corps investigation. These are the I-95 fill, the Dematteo land fill and the RESCO fill. These projects account for the major portion of wetland fill in the area and are also major factors in affecting the character and extent of the remaining wetlands. For example, approximately 20 acres of land bounded by Ballard St., I-95 fill, Bristow St. and Eastern Ave. in Saugus was saltmarsh in 1967. Because of the restriction to the movement of water caused by the I-95 fill, the area does not meet the definition of wetlands described in the Corps Wetland Delineation Manual. Areas which have lost their character as wetland but still lie below the elevation of the line of periodic tidal influence will be an inviting target for developers. Unless a clear and defended line of jurisdiction is established for those areas continued filling activities can be expected.

It may be possible that a few small areas on the perimeter of the marsh were filled after 1968 but were undetected due to an absence of aerial photographs or other evidence that would reveal those fills. If there are any such fills they would be few and insignificant.

RESULTS: The following information was obtained from investigating the identified sites within the study area:

1) SAUGUS - IEP identified 10 sites and the Corps identified an additional 9 sites within Saugus. Of the 19 sites investigated 13 have been determined to be undetectable or prejurisdiction fills, 2 sites were authorized by permit and 4 sites have been opened as cases in Enforcement. Since 1968 a total of approximately 75,000 sq. ft. of wetlands have been filled. Of the total amount of wetlands filled about 40,000 sq. ft. was unauthorized. Since 1978 about 35,000 sq. ft. of the total was deposited.

2) LYNN - IEP identified 5 sites and the Corps had 1 of those sites already identified within Lynn. Of the 5 sites investigated 3 have been determined to be undetectable or prejurisdiction fills, 1 site was authorized and 1 site was opened in Enforcement and deferred to State action. Since 1968 a total of approximately 212,500 sq. ft. of wetlands was filled. Of the total amount of wetlands filled about 12,500 sq. ft. was unauthorized and this was deposited after 1978.

3) REVERE - IEP identified 9 sites and the Corps identified another 8 sites within Revere. Of the 17 sites investigated 8 have been determined to be undetectable or prejurisdiction fills, 2 sites were authorized, and 7 sites have been opened as Enforcement cases. Two of the Enforcement cases are small fills and would be likely candidates for local action. Since 1968 a total of approximately 210,500 sq. ft. of wetlands was filled. Of the total amount of wetlands filled approximately 126,000 sq. ft. was unauthorized. Since 1978 about 160,000 sq. ft. of fill was placed in wetlands. About 5,500 sq. ft. of this amount has been removed through voluntary restoration.

4) Since July 1988 when an Enforcement Point of Contact was publicized for the estuary, the Enforcement Unit responded to all complaints from local groups and private citizens. During the first five months these actions have resulted in observing 1 permitted action and issuing 5 Cease and Desist orders. To date 2 of these cases have resulted in voluntary restorations and the other 3 cases are in various stages of negotiations with restoration as the priority objective. An additional 2 Cease and Desist Orders were issued following Corps surveilllance of the area.

Also, contacts have been established between the federal, state and localregulatory authorities in the area to coordinate enforcement efforts. With the network of agencies and concerned groups in the area it is extremely unlikely that any future fills will go undetected.

SUMMARY: The Enforcement Unit evaluated 41 sites within the Lynn, Saugus and Revere marsh complex. IEP identified 24 sites with changes in vegetation and the Corps identified another 17 sites as potential or confirmed unauthorized fills. The number of investigated sites can be grouped as follows:

1) Undetectable or prejurisdiction fills - 24
2) Permitted fills - 5
3) Cases opened in Enforcement - 12

Excluding the I-95, Dematteo, and RESCO fills, the areas that those fills have impacted and possibly a few small undetected perimeter fills, the following list is an estimate of the amount of fill placed within Corps jurisdiction in the area:

1) From 1968 to 1988 fill was detected at 17 sites covering a total area of 11.5 acres.
2) From 1978 to 1988 fill was detected at 12 sites covering a total area of 4.7 acres.
3) From 1968 to 1988 unauthorized fill was detected at 12 sites covering a total area of 4.1 acres.
4) From 1978 to 1988 unauthorized fill was detected at 10 sites covering a total area of 3.9 acres.

Between July and November of 1988 the Enforcement Unit issued 7 Cease and Desist orders for sites within the area. At the present time 2 cases have been voluntarily restored, 2 cases are preparing plans for voluntary restoration and 1 case is being negotiated with restoration as the objective. The remaining 2 cases had just been initiated and their disposition was dependent on a response from the individuals. Figure 1A shows the location of sites investigated.

REVERE BEACH RESERVATION

The Revere Beach Reservation dates back to 1895. The existing four sets of open-aired pavilions were constructed in 1897 and 1904, about the same time as the Metropolitan District Commission (MDC) police station. The reservation, which is owned and operated by the MDC, runs from Eliot Circle to Carey circle, at the north end of the beach, about two and a half miles. It was the first public beach with facilities in the U.S. The beach has enjoyed a long history with reportedly 500,000 people using the beach on a peak day. The central part of the beach for several decades was an amusement center as well. When the attractions started deteriorating, attendance declined sharply. Today the amusements have been removed and some improvements in 1978 and 1979 have caused about a 10 percent increase in attendance to around 25,000 people on a peak day according to the MDC. The beach is open and used year round for passive recreation.

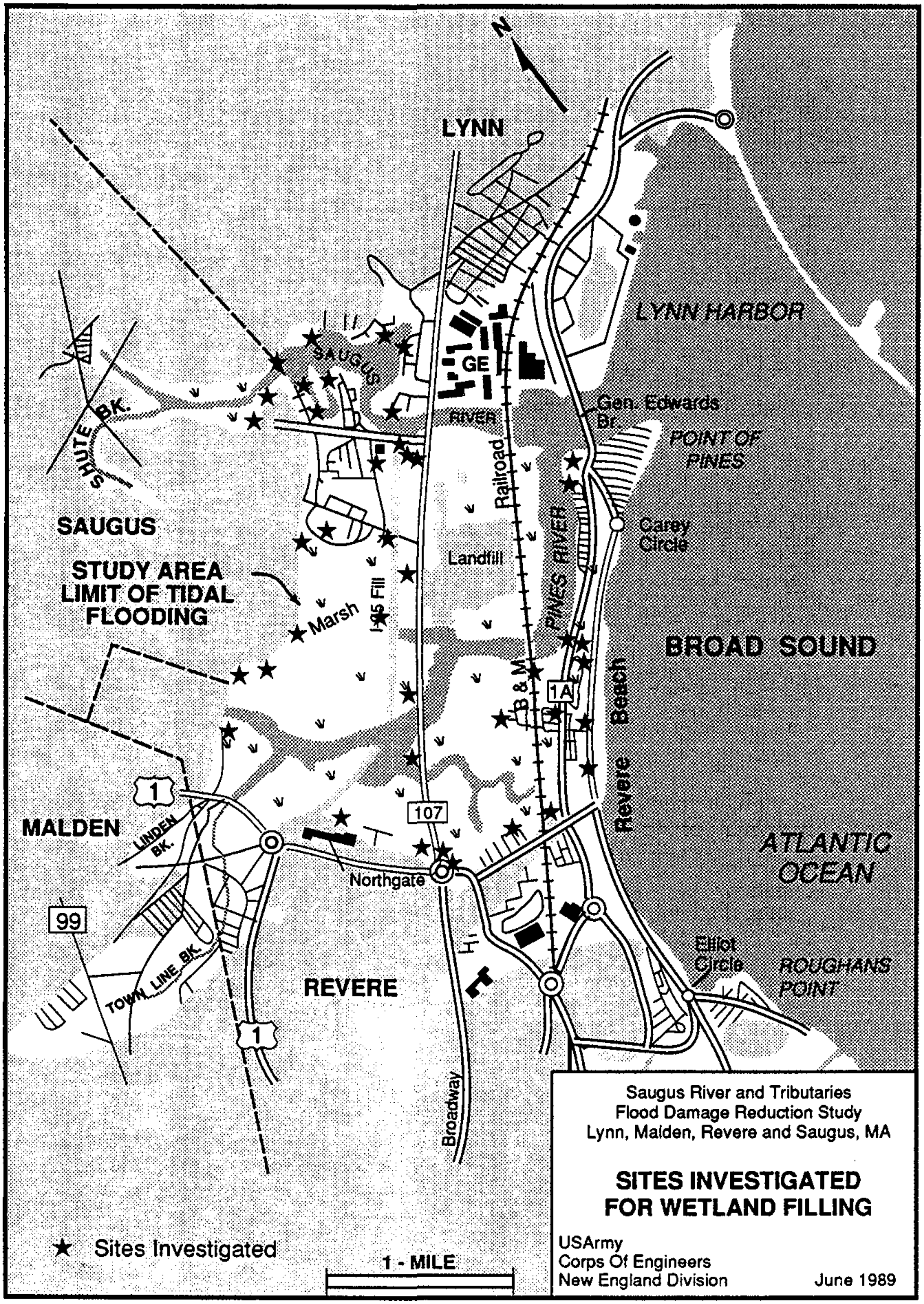

N
LYNN
LYNN HARBOR
SAUGUS
RIVER
GE
Gen. Edwards Br.
POINT OF PINES
SHUTE BK.
SAUGUS
Railroad
Carey Circle
Landfill
PINES RIVER
STUDY AREA
LIMIT OF TIDAL FLOODING
Marsh
I-95 Fill
BROAD SOUND
B & M
1A
Revere Beach
1
MALDEN
LINDEN BK.
107
Northgate
ATLANTIC OCEAN
99
TOWN LINE BK.
REVERE
Elliot Circle
ROUGHANS POINT
1
Broadway
Sites Investigated
1 - MILE
Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
SITES INVESTIGATED
FOR WETLAND FILLING
USArmy
Corps Of Engineers
New England Division
June 1989

Figure 1A

The eroded condition in accessible parts of the beach has also contributed to the decline in attendance. In the central and northern sections of the beach (Reaches B and D) tides lap at the seawalls for hours before and after high tide.

The major parking areas are located in the Wonderland area (Reach B). Parking is also available along the 2 1/2 miles Revere Beach Blvd. Crescent Beach (Reach A) about 200 feet wide at high water is crowded on peak days. Space is generally available in Reach C.

The Master Plan for the reservation includes demolition of the bathhouse and laundry building attached to the Ocean Ave. side of the Police Station. Construction is planned for:

- a new garage to the north end of the police station (Reach B6).
- a new raised parkland located on the cleared land between Ocean Avenue and Revere Beach Parkway running from either side of the Police Station to hold back flood waters, and provide lawns, sidewalks, landscaping for recreation, and have a rolling irregular ridgeline 10 to 15 feet above existing round (Reaches B5 and B7).
- a secondary granite sitting wall along the boulevard which would also provide a retaining wall for a flood water storage basin (B5 to B7).
- road ramps in the vicinity of (1) Shamut St. on the north side of the police station over the embankment and (2) a ramp on the boulevard just north of the beach St. Pavilion (in Reach B1) to complete the flood water storage basin at the south end. This ramp would create high ground from the park embankment to the seawall.
- beach restoration in Reach A, B, C1 and C2 (the northern limit of the Master Plan).
- construction of major pedestrian entrances to the parkland and beach (Reach B5), i.e. from the Wonderland MBTA Station similar to the one completed for the Revere Beach MBTA Station.
- other features generally in Reaches B5 to B7 include for example: a renovated sanitary and a new small bathhouse; improved drainage, extensive lighting, benches, drinking fountains; a boardwalk along a narrowed boulevard which would be closed to traffic in the summer, and raising Ocean Avenue.

The phasing of these improvements is described in the Master Plan; however construction dates have not been set since it is dependent on funding. It is assumed the bathhouse would be removed within the next 10 years by the MDC. The total cost of the Master Plan at December 1978 price levels was $54,000,000 which includes: $18,000,000 for beach restoration; 2,300,000 for pavilion restoration; $8,800,000 for demolition and construction of seawalls from Eliot Circle to Oak Island St. Pavilion;

and $7,500,000 for park structures and development and $17,400,000 for other features primarily roads, utilities, walkways, secondary seawalls and other MDC and beach facilities.

Phase 1 of the Master Plan was accomplished in 1978 and 1979 at a cost of $1.1 million. It included demolition of buildings and clearing the area for the park embankment (Reach B5 & B6). This short section of the park was constructed behind Reach A2 between the Revere Beach MBTA Station, and the Shirley Ave/Beach St. Pavilions. Other improvements have included renovation of the MDC Police Station. Restoration of the pavilions are scheduled.

The proposed parkland would provide significant benefits to the Reservation in its appearance and diversity of use. The proposed park excluding the completed Phase 1 Park, between Beach Street and Revere Street, (3800 ft. long by 80 to 100 ft. wide) would have a usable recreation area of about 280,000 square feet and a comfortable capacity of 3700 people.

NAVIGATION

There are about 400 vessels that use the Saugus and Pines Rivers for navigation and including about 350 which pass through the existing 100 foot wide, 27 foot high (when bridge deck is closed) navigation opening under the General Edwards Bridge. The 350 vessels include 280 recreational power and sail boats, and 70 commercial lobster and/or finfish boats upstream of the General Edwards Bridge (Gen. Ed. Bridge). In addition the General Electric River Works is serviced by fuel barges about once a month. There are several hundred additional vessels in Lynn Harbor and Point of Pines Yacht Club.

RISING SEA LEVEL

Sea level has been rising world wide at various rates for thousands of years as a result of retreating glaciers. The most recent historic rate of rise in the project area has been based on data collected from the Boston NOS gage from 1922 to 1980 and is estimated at about 0.008 ft/yr or slightly less than 1-foot/100-years. In recent years there has been much discussion regarding a potential increased rate of future sea level rise. This phenomenon is related to a gradual warming of the earth's atmosphere associated with increased emissions of carbon dioxide and other gasses on earth. The warmed atmosphere may promote expansion of near surface ocean water and increase the rate of melting glaciers, thereby hastening the rate at which ocean levels appear to be rising. The scientific community appears in general agreement that the rate of global sea level rise will increase; however, there is lack of precision and agreement as to how much the increase will be.

In one of the most recent reports published, in 1987, the National Research Council recently suggested that the sensitivity of design calculations and policy decisions be evaluated based on three plausible variations in sea level rise to the year 2100, all showing greater rate of rise in the distant future than in the next decade and all with an increased rate of rise relative to the present: 1.6, 3.3 and 4.9 feet. In the Corps most recent document, published in January 1988 by the Board of Rivers and Harbors, it was suggested that Corps projects should be evaluated using as a minimum, the historic rate of rise, and also completing a sensitivity analysis for the Project using the NRC's findings. Additional information is provided in the Hydraulics and Hydrology Appendix.

FLOOD LEVELS AND FREQUENCIES

In 1984, five automatic recording gaging stations were installed and operated by the U.S. Geological Survey in the study area to determine tide levels. Two stations were located in Broad Sound: one at Simpson's Pier at Roughans Point and one at Bay Marine's Gas Wharf Inlet in Lynn Harbor. One was installed on the Saugus River at the Route 107 draw Bridge, and two on the Pines River: one at Broad Sound Tuna Club (lower river) and one at Atlantic Lobster, on the east side of Route 107.

The Corps' Waterways Experiment Station prepared a hydrodynamic model of the estuary calibrated to normal tide levels. The calibrated model was used to predict storm tide - frequency in the Saugus and Pines Rivers and Broad Sound using Boston gage records. Topo mapping of the area and surveys of bridges and the river bottoms were provided for the model effort. Figure 1b shows the results of the model effort. The resulting tide data for the estuary had a high degree of confidence, especially east of Route 107 since gaging stations data was used. West of Route 107 the results are very preliminary. West of 107 the Corps collected additional gaging data to evaluate these areas. To be explained in the next section over 500 interviews were held resulting in establishing high water marks collected throughout the study area to assist in developing flood stage frequencies on developed land.

EXISTING SHOREFRONT STRUCTURES

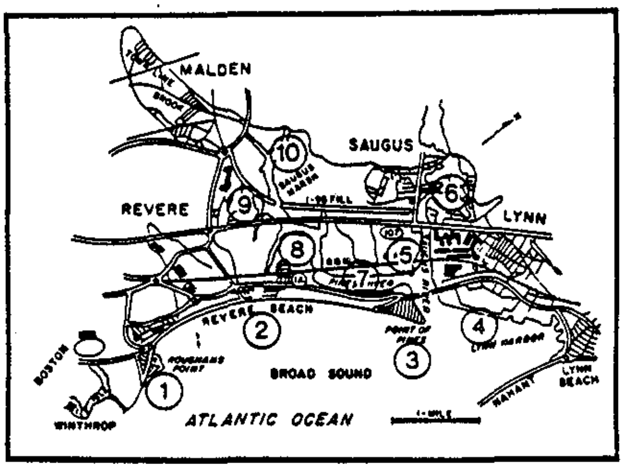
The study area has over 30 miles of existing shorefront structures along Revere Beach, Lynn Harbor and the Saugus and Pines Rivers Estuary Shorefronts. The structures include steel, concrete, granite and timber walls; and rock, rubble, shrubbery and grass-faced embankments. Their purpose are to hold back soil from erosion, break waves, reduce wave overtopping and flooding and to act as retaining walls to hold soil in place. About two miles of boat, fishing and commercial piers are located along the Saugus and Pines Rivers.

Vollmer Associates completed a shorefront inventory and assessment of the replacement costs, maintenance, and structural life of a major portion of the shorefront in 1986. This information has been supplemented over the past year with completion of the overall inventory for shorefront structures valued at over $65 million (1986 price level). Addendum #2 shows the "Summary of the Shorefront Inventory and Analysis", and estimated replacement and maintenance costs. Revere Beach seawalls are not included since the Erosion Control Project eliminate most storm damage

TIDE STAGE VS. FREQUENCY CURVE COMPARISON

LOCATION	SPN	500 YEAR (0.2%)	100 (1978) (1%)	50 YEAR (2%)	10 (1979) (10%)	1.1 YEAR (99.9%)
		TIDE EVENT & FREQUENCY				
	STILLWATER TIDE STAGE (ELEVATION, FT. NGVD)					
BOSTON HARBOR	12	11.2	10.3	9.9	9.1	7.9
BROAD SOUND*						
1-ROUGHANS POINT	NOT DETERMINED	11.3	10.4	10.0	9.2	7.8
2-REVERE BEACH		11.2	10.4	10.0	9.1	7.8
3-POINT OF PINES		11.2	10.4	10.0	9.2	7.8
4-LYNN HARBOR		11.2	10.4	10.0	9.2	7.8
SAUGUS RIVER*						
5-EAST OF RT. 107		11.3	10.6	10.2	9.3	7.9
6-WEST OF RT. 107		11.5	10.7	10.2	9.3	8.0
PINES RIVER*						
7-MOUTH TO B & M R.R.		11.3	10.5	10.1	9.2	7.9
8-B & M R.R. TO RT. 107		11.7	10.7	10.3	9.2	7.7
9-RT. 107 TO I-95 FILL		11.9	10.8	10.4	9.3	7.7
10-WEST OF I-95 FILL		11.9	10.8	10.4	9.3	7.7

*PRELIMINARY DATA DEVELOPED IN 1985 BY THE CORP'S WATERWAYS EXPERIMENT STATION FROM A NUMERICAL MODEL CALIBRATED USING THE BOSTON NOS GAGE AND FIVE GAGE STATIONS INSTALLED IN 1984 BY THE U.S.G.S. IN THE STUDY AREA.



AUGUST 1986 PRELIMINARY

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

STUDY AREA

TIDE STAGE VS. FREQUENCY

US Army Corps of Engineers
New England Division

FIGURE 1B

to seawalls. These structures are the first line of defense against tidal surges, flooding and wave action along the coast and riverbanks. Slight to severe deterioration is evident all along the shoreline. Generally, the structures were not designed for coastal storms, wave action, highwater, saturated soil and flood conditions. As a result are significant damages: rapid deterioration, erosion from overtopping, and sliding of rock and rubble off embankments.

Damages to piers results from uplifiting of decks, loosening of fasteners, rotting of connections and damage from wave action.

OVERTOPPING OF SHOREFRONT STRUCTURES

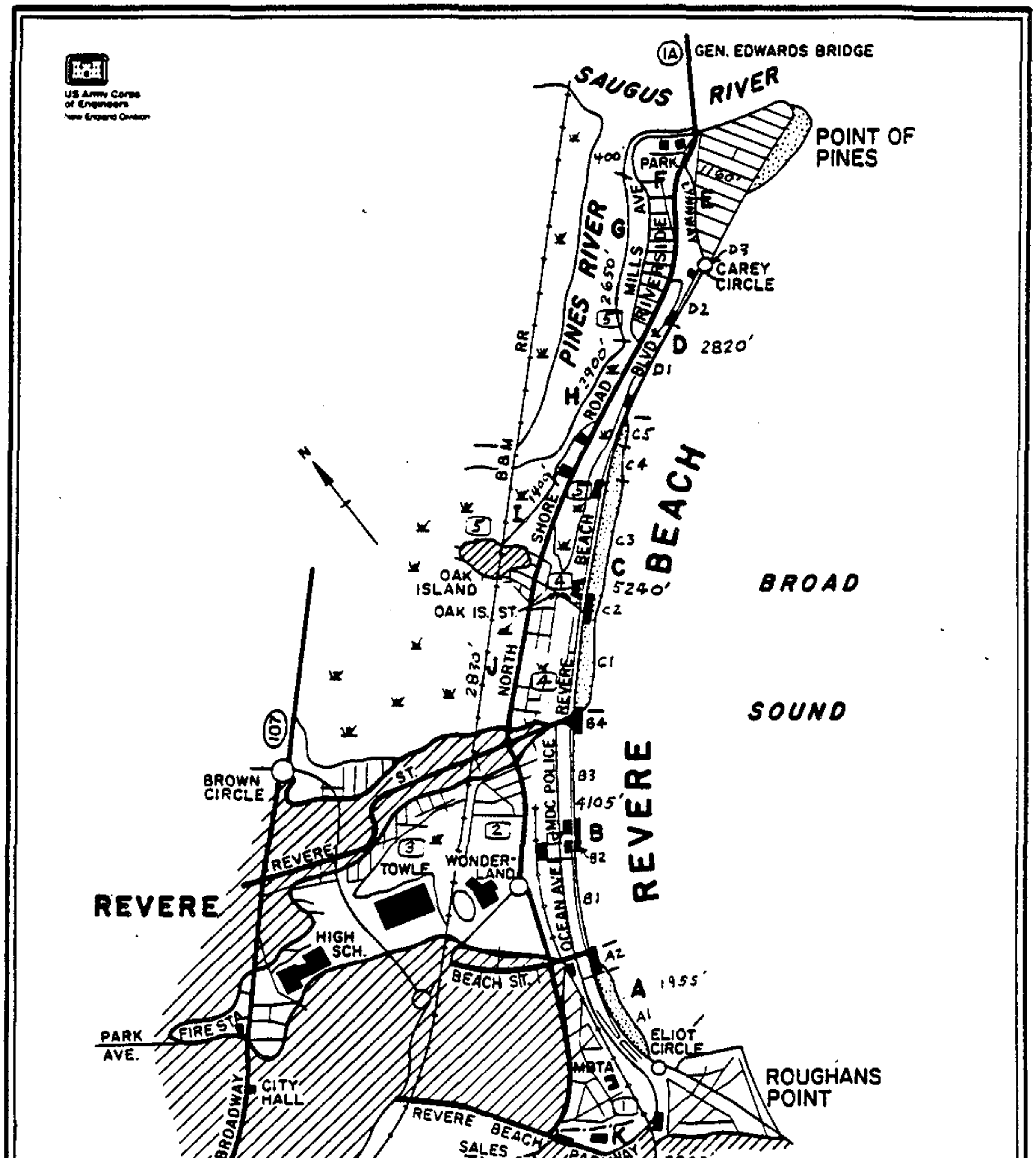
The study area was divided into a number of geographic areas with five areas identified as having concentrated damages. They are:

Revere Beach Backshore, City of Lynn,
East Saugus, Town Line Brook, and Northgate.

These areas were investigated as local protection areas. Their shorefronts were surveyed and evaluated to determine their potential for being overtopped by storm tides.

REVERE BEACH BACKSHORE - Topographic mapping was obtained at a scale of one inch equals 100 feet, with two foot contours and spot elevations at each building. In addition, land surveys were obtained along the Revere beach seawall and beach along roads and railroad embankments. Table 2 shows the type of shorefront features, top elevations and top of runup for designated reaches around the perimeter of the Revere Beach Backshore Area (Plate 1). The volume of water overtopping the shorefront is a factor of the intensity of the storm's winds, waves, wind direction, depth of water fronting the structure at the shorefront, the slope of the structure and other variables. Table 2 summarizes the results of wave runup for three storm tide stillwater levels E.L.10.3, 11.2 and 12.0 ft. NGVD. Under 1989 tidal conditions, these storm levels have been assigned recurrence intervals of 100 year, 500 year and the SPN events. The stillwater level is the storm, level of the tides without the wave action. The assigned frequency is based on historical data in Boston Harbor. The top elevation of runup is the top elevation storm tide waters reach after waves hit and run up above a structure. The higher the top of runup is above the structure's top elevation, the greater is the volume of overtopping. Generally in the first foot of runup above a structure there is very little water. The volume of water overtopping increases exponentially as the top of runup rises above the structure.

Along Revere Beach two areas show the potential for significant overtopping at the 100 year (1978), 500 year and SPN storm tide levels. One area is reaches B1-B4(1) running from the north end of the Band Stand Pavilion 1&2 (north of Beach Street) to Pavilion #5 at the end of Revere Street. The other area of overtopping is at the north end of Revere Beach from the north access ramp past the concrete steps to the northern circle, reaches C5 and D1-2.



REVERE BEACH BACKSHORE

LOCAL PROTECTION AREA

PLATE 1

TABLE 2

Revere Beach Backshore
EXISTING SHOREFRONT STRUCTURES AND RUNUP

Reach	Length (feet)	Existing Structure Description	Structure Top Elev.	Top Elevation of Runup (ft. NGVD) 100 Year	500 Year	SPN
		(Stillwater Tide Levels:)		(EL.10.3)	(EL.11.2)	(EL.12)
A1	1430	Wall	16.2	12.3	13.2	14.0
A2	525	Wall, Pavilion 1&2	19.3	13.0	13.9	14.7
B1	1475	Wall	16.4	18.7	21.6	26.8
B2	570	Wall, Pavilion 3&4	20.4	28.4	30.9	33.0
B3	1515	Wall & Apron	16.8	17.0	18.5	19.5
B4(1)	270	Wall, Pav. #5	18.0-20.6	23.7	26.5	30.0
B4(2)	275	Wall, Pav. #6	18.0-20.6	13.7	14.7	15.9
C1	1355	Wall	16.9	13.7	14.7	15.9
C2	565	Wall, Pav. 7&8	20.4	13.7	14.7	15.9
C3	1360	Wall	16.1	12.5	13.5	14.4
C4	1300	Wall	15.9	12.9	13.9	14.8
C5	660	Wall	15.9	21.4	22.3	24.8
D1	1480	Wall & Steps	15.9	21.4	22.3	24.8
D2	900	Wall	15.8	16.4	17.9	20.1
D3	(See Point of Pines Reach A)					
E	1160	Lynnway	11.0-13.3	-	-	-
			Pines River Stillwater Tide Levels:			
F	400	Gibson Park	7-10	10.5	11.3	12
G	2650	Riverbank	7-9		(Overtopped	
H	2900	Rt.107 & Bank	8-9.5		From	
I	1400	Ground	6-10		Pines	
J	2730	B&M RR Bed	7-12		River)	
K	1500	Parkway	10-14	Overtopping above 100 year level.		

Interviews with residents and highwater marks, discussed in the next section, confirmed the tremendous amount of water which overtopped these reaches of seawalls in 1978.

Also confirmed was that no overtopping occurred for Crescent Beach, Reaches A1-2, and the area just north of Revere Street from Pavilion #6 to and including Reaches C1-4 for the beach fronting Oak Island Street. These two beaches have been stable or accretting (building up naturally) since the beach was first surveyed in 1900. Discussion with oceanographers who have investigated the beach expect the beach to remain stable in the future as long as its maintained.

The two eroded sections are locations where refracted waves result in a concentration of energy being disapated causing faster erosion and loss of sand.

Reach E is the Lynn Way. Water in 1978 overtopped Point of Pines shorefront and flowed over the Lynn Way.

Reaches F to J are overtopped from Gibson Park past Oak Island to Revere Street from tidal surges up the Pines River. Almost the entire Pines River stretch is overtopped by 10 year frequency storms (Stillwater level EL.9.2) and more frequent events. The same is true for the Reach B seawall which MDC reported overtopping occurs many times each year.

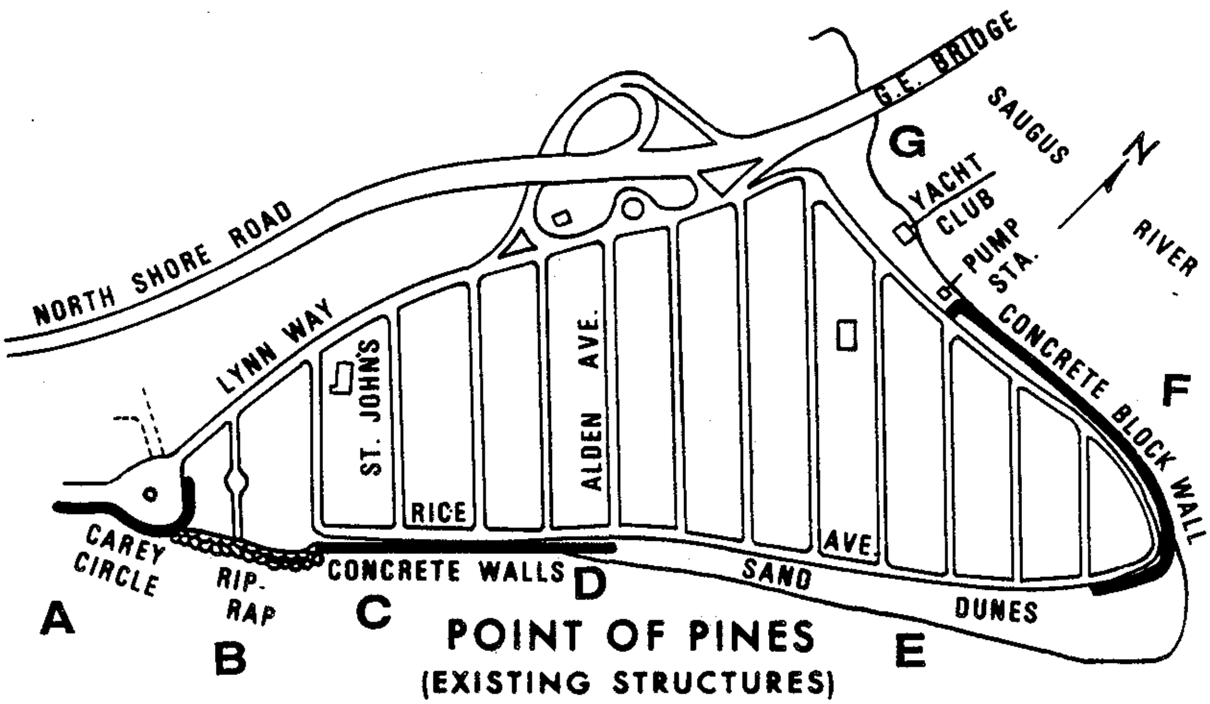
The Revere Beach Backshore area is flooded frequently based on both the reports of interviews, confirmed with photographs, Corps observations during storms and based on analysis of runup conditions.

POINT OF PINES - The Point of Pines topo maps were obtained concurrent with Revere Beach Backshore in 1981 with spot elevations at each building. The most recent land survey was accomplished all along the shorefront in 1986 at a scale of one inch equals 20 feet and one foot contours. Table 3 shows the type and top elevations of existing shorefront structures and the runup reported in the Corps' Point of Pines Detailed Project Report for Coastal Flood Protection, dated October 1984. Plate 2 shows a plan of Point of Pines.

Reach A, Carey Circle or the Northern circle of Revere Beach was significantly overtopped in 1978, as confirmed by the runup analysis. Reach B contributes the most amount of water into Point of Pines from overtopping, and Reach C and D to lesser amounts. Only at the peak of the 1978 flood did residents report the dunes being breached at an eroded walkway location at the south end of the dunes in Reach E. Residents also reported some overtopping of the reach F wall along the Saugus River. At Reach G the ocean poured in freely over the ground near the Yacht Club.

In 1978 and 1972 residents reported boulders in Reach B moved back toward the homes and also fell onto the beach. In 1978, the Reach C precast wall on boulders was undermined causing the collapse of the asphalt apron behind the wall. The Reach D wall is a sturdy cast in place wall. The Reach F precast block wall is in sections and sits on an exposed slab resting on rocks. There are spaces between the wall sections. The dunes in Reach E are eroded at the end of each street where foot traffic has killed the dune grass. A beautiful sandy beach fronts the dunes and is largely owned and maintained by the Point of Pines Beach and Conservation Association. The beach is naturally nourished by the net movement of sand toward the Point where a spit of sand has formed jotting out toward the east from the Point.

Reaches Along Shorefront "A to G"



POINT OF PINES
GENERAL PLAN

PLATE 2

Point of Pines is subject to severe flooding from overtopping along much of their shorefront and frequent flooding from overtopping by the Yacht Club. It was one of the hardest hit neighborhoods in the '78 storm. Residents remember the Blizzard of '78 as a freezing cold and wet night without electricity. Many waited overnight to be evacuated with their families.

State financing of their local protection project may have been a possibility had they been willing to turn their beach over to the state, a requirement under a special program administered by the state's Coastal Zone (CZM) Management Office for funding small coastal projects. They have owned and maintained their beach since the 1930's. Many residents are strongly opposed to free public access of their beach which they fear would over run the beach and dunes, degrading their neighborhood and damaging the sensitive ecology and wildlife of the dunes.

The city of Revere indicated that if Piont of Pines features were part of the Regional Plan (which they are for floodgate alignments 1 and 2), their beach would not likely be a requirement for state funding. The large Regional Plan would be separately funded by the state legislature and not be eligible for the CZM program.

TABLE 3

Point of Pines
EXISTING SHOREFRONT STRUCTURES AND RUNUP

Reach	Length	Existing Structure Description: Type	Existing Structure Description: Top	Detailed Project Report Top Elevation of Runup (ft. NGVD): 10 Year	100 Year	500 Year	SPN+1'
	(feet)		(EL.,ft.NGVD)	Stillwater Levels: EL. 9.0	EL.10.3	EL.11.2	EL.13
A	230	Wall	16.5	24.0	29.9	33.1	35.3
B	440	Riprap	14.7-15.9	17.9	19.6	21.1	23.0
C	430	Wall	16.4	-	16.7	27.7	35.5
D	450	Wall	15.4	-	14.7	18.2	24.0
E1	320	Dunes	12±-15	-	13.4	14.3	16.6
E2	350	Dunes	13-16	-	13.4	14.3	17.5
E3	500	Dunes	14-15	-	13.1	14.4	18.9
E4	600	Dunes	13-14	-	12.9	14.0	16.5
F	970	Wall	12-12.9	11±	12±	13±	15±
G	730	Ground	8.5-9.0	Tides Exceed Ground Level			

NORTHGATE - The Northgate area was evaluated using 1978, one inch equals 400 feet and 5 foot contour mapping. In addition ground surveys established first floor and ground elevation for each building. The following Table 4 shows the top of ground elevations for each Reach on Plate 3.

TABLE 4

NORTHGATE
EXISTING SHOREFRONT AND TIDE LEVELS

	Reach A	Reach B
Length (feet)	2950	2350
Shorefront Description:	Existing Ground	
Shorefront top elev. (Ft. NGVD)	7-10	7-10
Pines River Storm Stillwater Tide Elev.(Ft.NGVD):		
100 year	10.8	10.8
500 year	11.9	11.9
SPN	12.7±	12.7±

Table 4 shows the potential overtopping for severe storms.

TOWN LINE BROOK - Plate 4 shows the reaches for the shorefront which reduces tide waters from overflowing into the Town Line and Linden Brook floodplains. Both 1971 and 1978, 5 foot contour mapping was used in addition to 1985 ground surveys to evaluate the shorefront. Table 5 shows the shorefront features and elevations for each reach.

TABLE 5

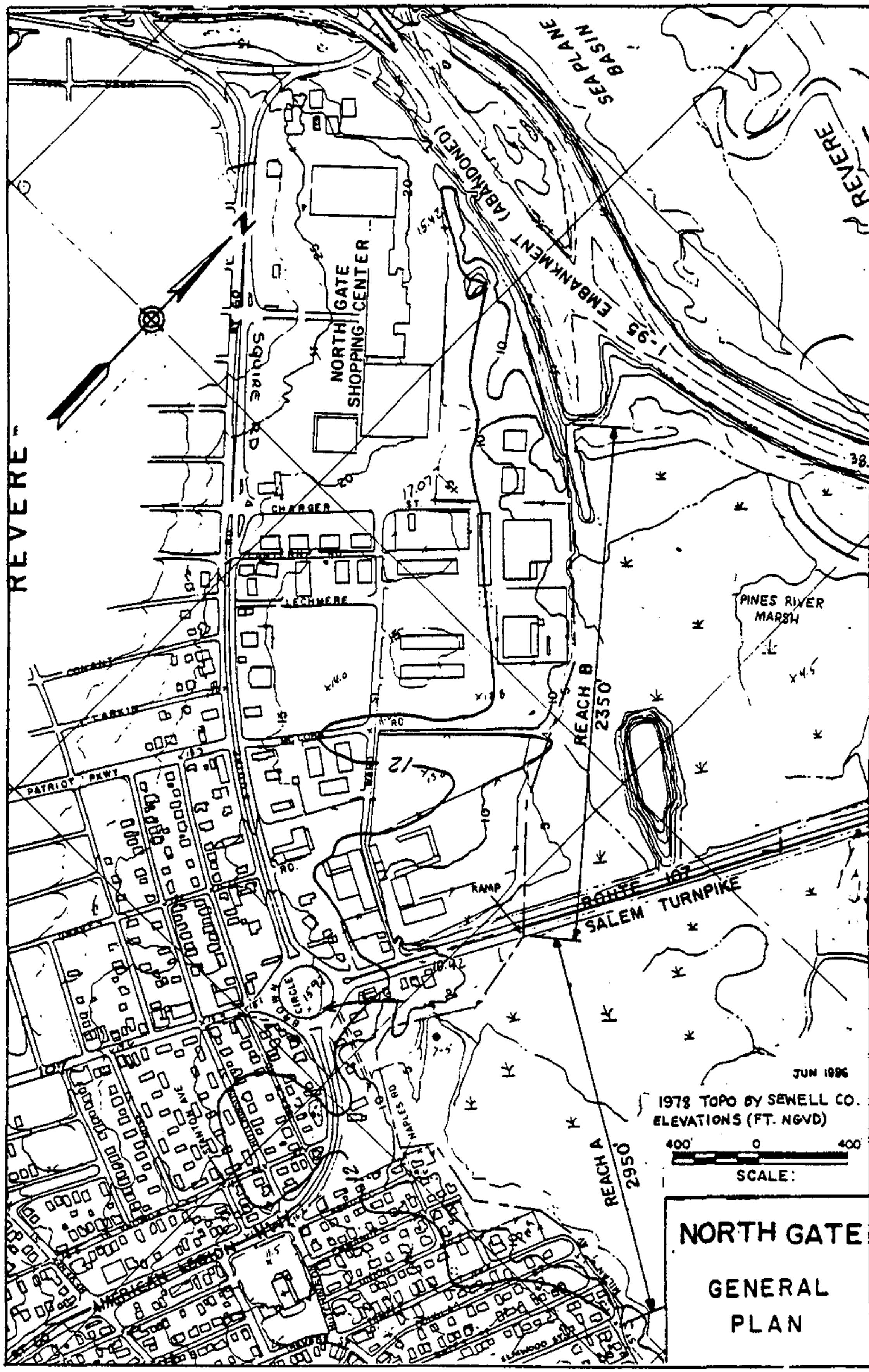
TOWN LINE BROOK
EXISTING SHOREFRONT AND TIDE LEVELS

	Reach A	Reach B1	Reach B2	Reach C
Length (Feet):	1100	200	600	1050
Shorefront Description:	(US #1 Road Surface)		Dike & RR	
Top Elevation (Ft.NGVD)	14.4 min.	12.8 min.	15	8.1-16

Pines River Storm Stillwater Tide Elevation (Ft. NGVD):

100 year	10.8	(same)
500 year	11.9	(same)
SPN	12.7±	(same)

Table 5 shows that overtopping Reaches A to B2 would not likely be a problem until reaching about the 500 year or SPN events when wind driven waves are likely to flood over onto U.S. Rt. 1. In Reach C however the



SEA PLANE BASIN
REVERE
EMBANKMENT (ABANDONED)
I-95
NORTH GATE SHOPPING CENTER
SQUIRE RD
REVERE
CHARGER
LECHMERE
CONANT
LARKIN
PATRIOT PKWY
PINES RIVER MARSH
REACH B
2350'
ROUTE 107
SALEM TURNPIKE
RAMP
CIRCLE
NAPLES RD
STANTON AVE
AMERICAN LEGION HWY
REACH A
2950'
JUN 1986
1978 TOPO BY SEWELL CO.
ELEVATIONS (FT. NGVD)
400' 0 400'
SCALE:
NORTH GATE
GENERAL PLAN

PLATE 3

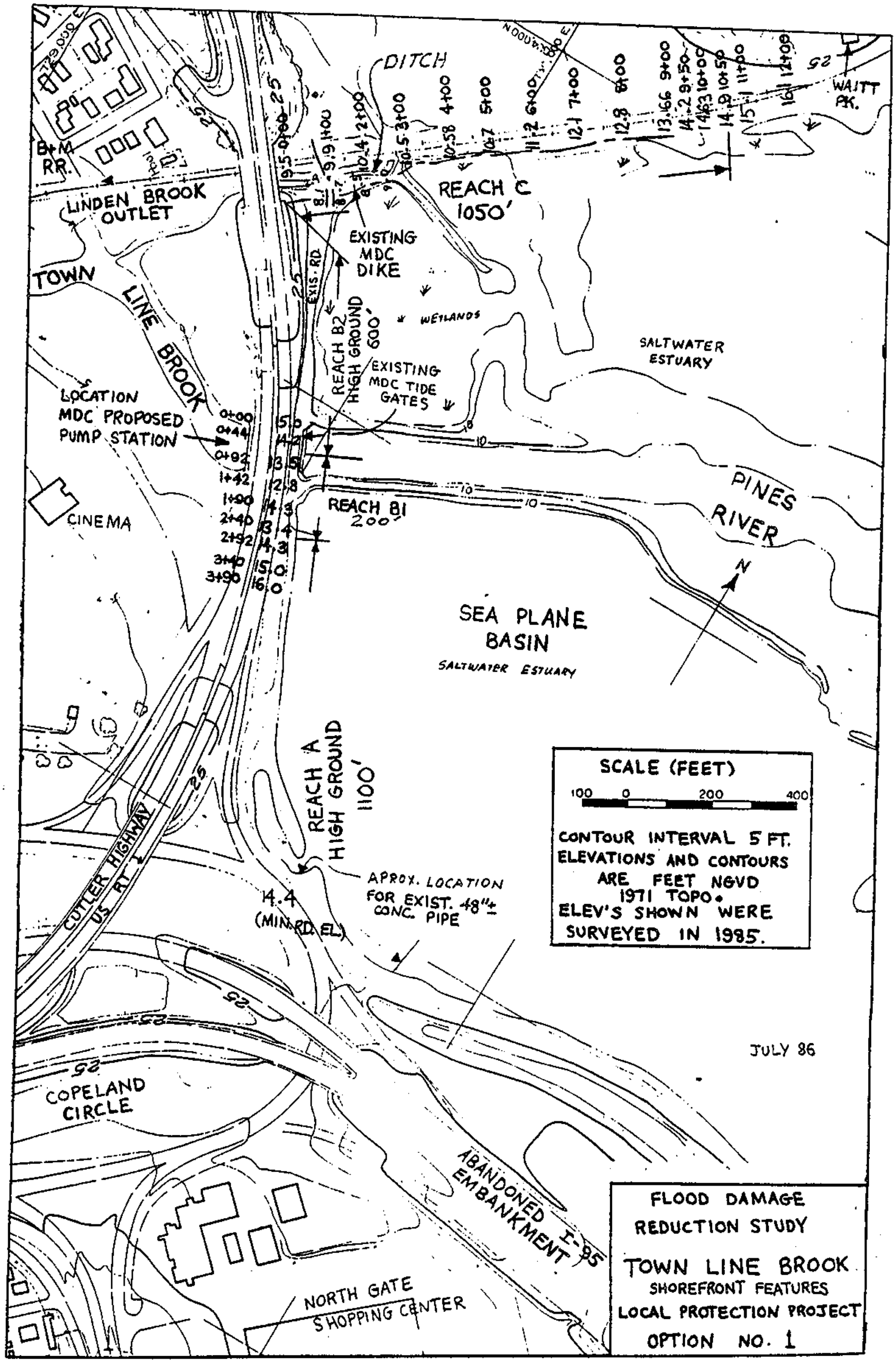

DITCH
WAITT PK.
B+M RR.
LINDEN BROOK OUTLET
REACH C 1050'
EXISTING MDC DIKE
TOWN LINE BROOK
REACH B2 HIGH GROUND 600'
WETLANDS
SALTWATER ESTUARY
EXISTING MDC TIDE GATES
LOCATION MDC PROPOSED PUMP STATION
CINEMA
REACH B1 200'
PINES RIVER
N
SEA PLANE BASIN
SALTWATER ESTUARY
REACH A HIGH GROUND 1100'
SCALE (FEET)
100 0 200 400
CONTOUR INTERVAL 5 FT.
ELEVATIONS AND CONTOURS ARE FEET NGVD
1971 TOPO.
ELEV'S SHOWN WERE SURVEYED IN 1985.
APROX. LOCATION FOR EXIST. 48"± CONC. PIPE
14.4 (MIN. RD. EL.)
CUTLER HIGHWAY US RT 1
JULY 86
COPELAND CIRCLE
ABANDONED I-95 EMBANKMENT
NORTH GATE SHOPPING CENTER
FLOOD DAMAGE REDUCTION STUDY
TOWN LINE BROOK
SHOREFRONT FEATURES
LOCAL PROTECTION PROJECT
OPTION NO. 1

PLATE 4

existing MDC dike, which prevents tides from flowing into the Town Line and Linden Brook floodplains, drops as low as elevation 8.1. At this elevation storm tides with a one year frequency at about EL. 8 probably overtop the dike sending a small amount of tide water into the ditch behind the dike which flows into the floodplain. For events exceeding a yearly occurrence, tide waters can be expected to contribute significant amounts of water into the Town Line and Linden Brooks and their floodplain. The MDC is scheduled to raise the shorefront, repair the existing tide gates, and construct a $25 million dollar pumping station and interior drainage improvements in the future. These MDC measures would considerably help reduce flooding for the projects' design event of a 50 year runoff coinciding with a mean high tide.

Reconnaissance studies of the Town Line and Linden Brook watershed were conducted by Vollmer Associates for this study to determine potential flooding in Revere and Malden. High water mark information revealed that in both the 1978 and 1979 events, flood levels reached about elevation 7 to 8 ft. NGVD in the lower part of the watershed. The most extreme flooding conditions are caused during periods of interior runoff accompanied by high tides, since the outlet of the Town Line Brook has tide gates which both prevent tides in the Pines River from backing up the brook, and retards drainage from the brook. In 1987 the brooks were reported to only reach the tops of their banks. The 1978 and 1987 storms were not accompanied by significant runoff as occurred in 1979.

A 1985 report on proposed drainage and pumping improvements for the watershed to reduce flooding was accomplished for the Metropolitan District Commission by Hayden-Wegman Inc. The report showed that during either a 10 or 50 year runoff event the difference in interior flood levels rose one foot when tides rose from a Mean High Tide of (4.8 ft. NGVD) to about a 5 year tide (EL. 8.3). Tides higher than this would significantly overtop the shorefront dike (minimum top elev. 8.1 ft. NGVD). Overtopping of the dike combined with interior runoff would likely increase flood levels by over one foot when associated with tides greater than EL. 8.3.

In the watershed runoff is retarded by under sized culverts. During a mean high tide only and a 50 to 100 year runoff, reported flood levels would be about EL. 12 ft. NGVD. If these runoff events are accompanied by coastal storms with very high tides, flood levels would likely be higher than EL. 12. In the EL. 12 floodplain there are about 800 buildings in Revere and 210 in Malden.

With the MDC's proposed project, flood levels would be substantially reduced. The design criteria is a 50 year runoff accompanied by a Mean High Tide. Since the MDC has funds to design the project, the Corps has assumed the project would be built. Therefore the only additional effort by the Corps was to estimate the cost of shorefront improvements needed to prevent tides from overtopping the shorefront into the watershed.

The cost of these shorefront improvements would either be incurred by the MDC for their project, or not be required with the Regional Floodgate Plan which would prevent overtopping of the shorefront. The cost savings would be benefits to the Regional Plan. Whether the MDC project is ultimately built or not, the Regional Plan would help to reduce flood levels in the watershed by preventing tide levels in the Pines River outlet of Town Line Brook from exceeding about EL. 8 ft. NGVD. This would allow flood waters in the watershed to flow faster through the existing MDC tidegates to the Pines River.

The Regional Plan's Saugus River Floodgates will not be operated to eliminate interior runoff flooding in the watershed. The MDC report shows that for their project's design condition their pumping station would need to draw water down to about EL. 2 ft. NGVD for the 50 year runoff event. The Floodgates would not be operated solely for runoff flooding. If it were operated for this or more frequent runoff conditions, ecological damage would likely occur to the estuary. The MDC reportd the dike would likely be raised to provide a 100 year tide level of protection , without the Regional Plan.

EAST SAUGUS - The East Saugus area was evaluated for shorefront overtopping and flooding using 1974 Massachusetts DPW topographic mapping at a scale of one inch equals 100 feet and two foot contours. To obtain elevations of ground levels near each building and the buildings first floor elevation for damage surveys, ground surveys were used. At the same time road and high water mark elevations were also obtained.

Table 6 and Plate 5 show the reaches and top elevations of shoreline structures. Also shown are the rivers stillwater tide levels for various frequency floods. Actual storm water levels can range up to about two feet higher in some areas due to about two foot waves and winds forcing the water higher on land. As shown in the table, East Saugus' entire perimeter is subject to overtopping for the 100 year event. In addition starting with a one year tide of about EL. 7 in Reach A and EL.8 in Reaches B to H, frequent flooding is a problem as substantialted by interviews, photographs and field investigations during and following storm conditions.

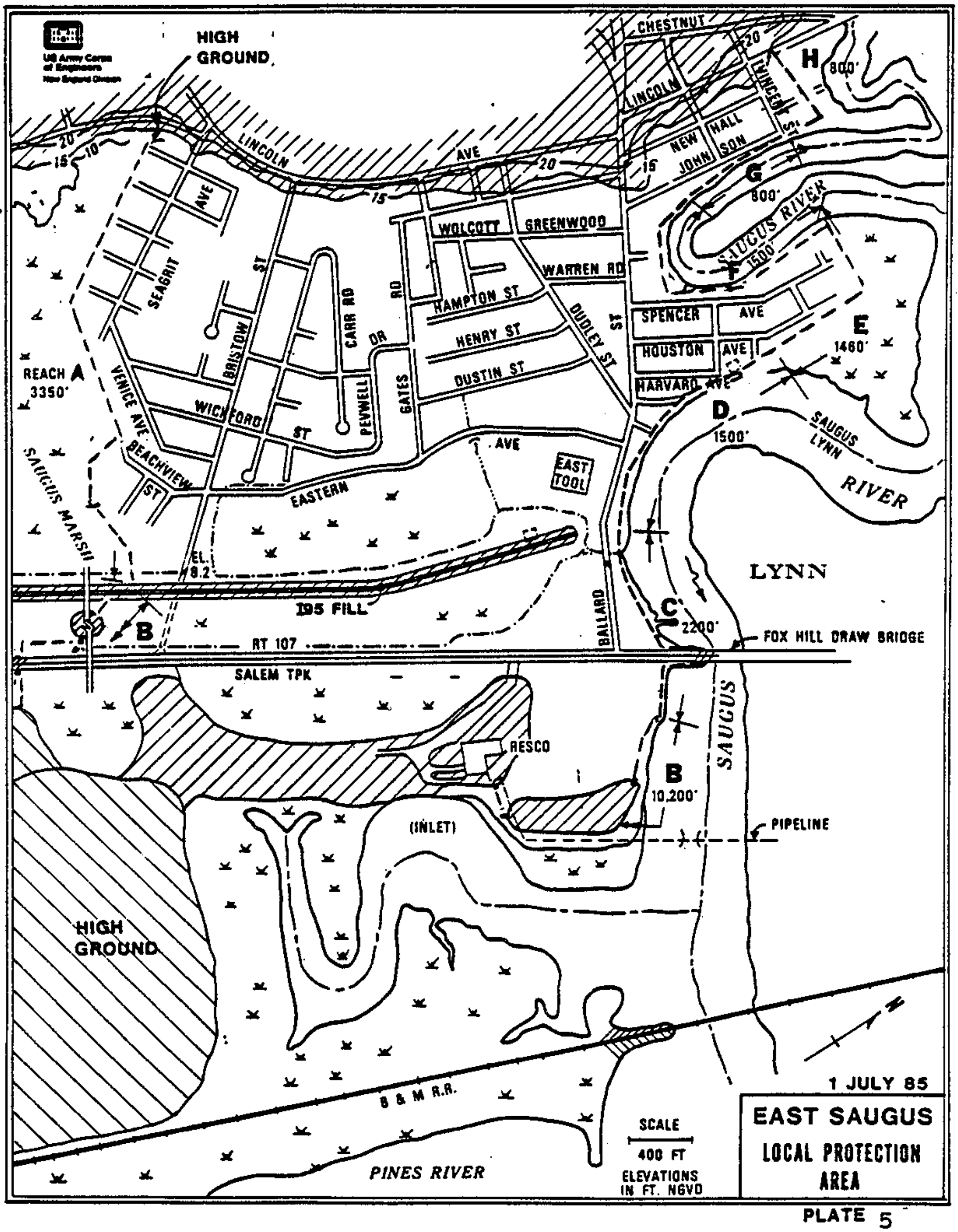

US Army Corps of Engineers New England Division
HIGH GROUND
LINCOLN AVE
CHESTNUT
LINCOLN
NEW
JOHN
HALL
SON
VINCENT ST
H
800'
G
800'
SAUGUS RIVER
F
1500'
WOLCOTT
GREENWOOD
WARREN RD
HAMPTON ST
SPENCER
AVE
HOUSTON
AVE
HARVARD AVE
HENRY ST
DUSTIN ST
DUDLEY ST
E
1460'
D
1500'
SAUGUS LYNN
RIVER
SEAGRIT
AVE
BRISTOW
ST
CARR RD
RD
DR
PEVWELL
GATES
WICKFORD ST
REACH A
3350'
VENICE AVE
BEACHVIEW ST
SAUGUS MARSH
EASTERN AVE
EAST TOOL
LYNN
EL. 8.2
I95 FILL
BALLARD
C
2200'
B
RT 107
FOX HILL DRAW BRIDGE
SALEM TPK
RESCO
B
10,200'
SAUGUS
(INLET)
PIPELINE
HIGH GROUND
N
1 JULY 85
B & M R.R.
PINES RIVER
SCALE
400 FT
ELEVATIONS IN FT. NGVD
EAST SAUGUS
LOCAL PROTECTION AREA

PLATE 5

TABLE 6

EAST SAUGUS
EXISTING SHOREFRONT AND TIDE LEVELS

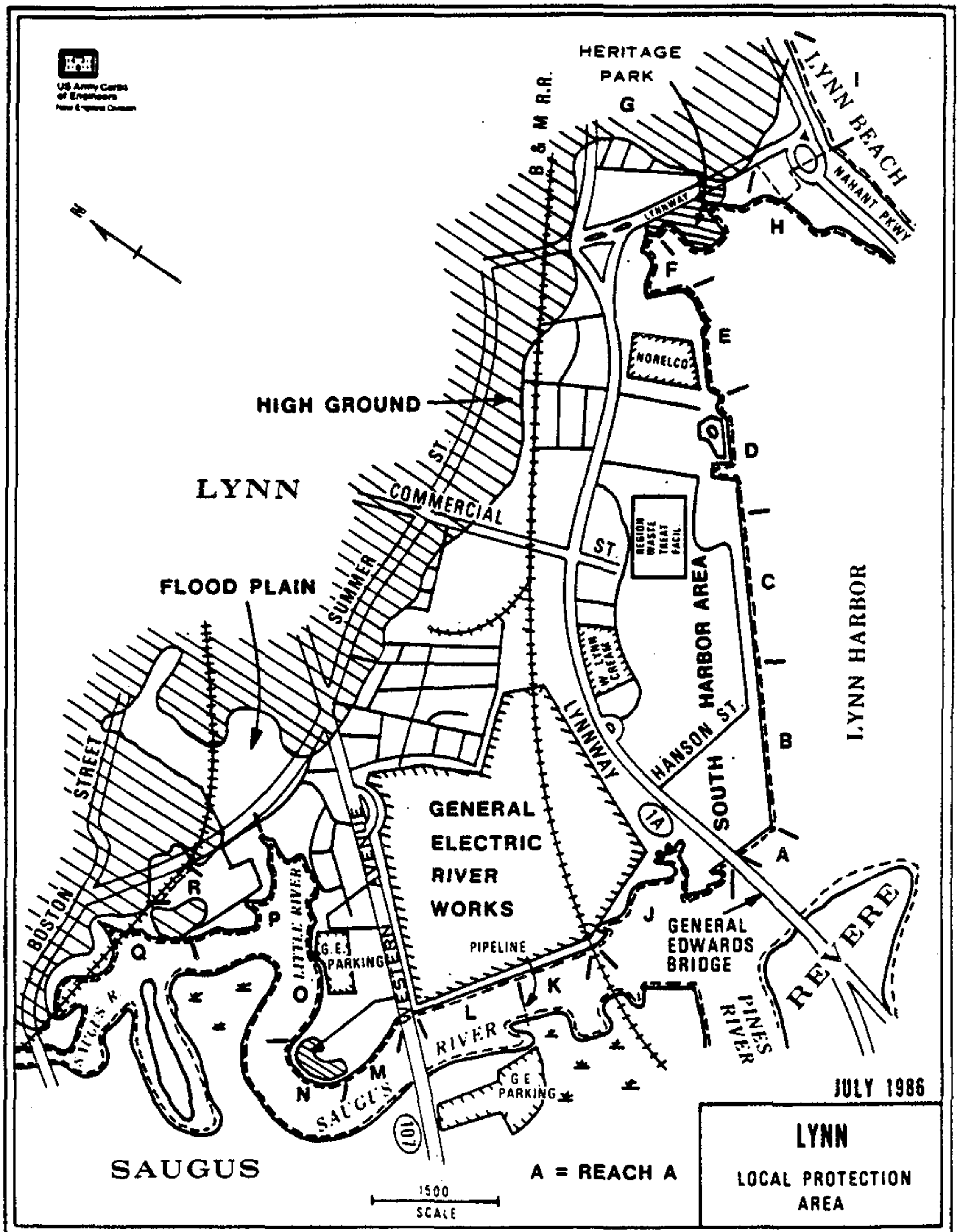
Reach	Length	Existing Structure Description	Structure Top Elev. (ft.NGVD)	Saugus or Pines Rivers Storm Tide Stillwater Level (ft. NGVD) 100 Year	500 Year	SPN
A	3350	Earth Berm or Ground	6-10	10.8	11.9	12.7±
B	10,200	Ground	8-16±	10.6	11.3	12.1±
C	2200	Walls/Riprap	6-8	10.7	11.5	12.3±
D	1500	Ground/Walls	6-11	10.7	11.5	12.3±
E	1460	Ground	6-8	10.7	11.5	12.3±
F	1500	Ground/Walls	7-8±	10.7	11.5	12.3±
G	800	Ground	10±	10.7	11.5	12.3±
H	800	Ground	8-10	10.7	11.5	12.3±

CITY OF LYNN - Topographic mapping (1"=100') previously developed for others using 1983 aerial photography was acquired in 1986 and 2 foot contours added. In addition ground surveys of first floors and ground elevations at all buildings as well as high water marks were obtained. In Reaches A to C ground topo mapping of the area and beach was provided by TransContinental Development Corp. at a scale of one inch equals 40 feet with spot elevations on the walls, beach and ground. Plate 6 shows the reaches along the Lynn shorefront, top elevations, lengths and storm stillwater tide levels in Broad Sound and the Saugus River.

Along Lynn Harbor 1978 flooding was reported from overtopping along the waterfront from Reaches A to H and over the Lynn Beach seawall Reach I. For the January 1987 flood, Corps interviews and observations revealed overtopping along the entire length, except at Heritage Park in Reach G. As exident in Table 7, all reaches are subject to overtopping well below the 100 year level keeping in mind that a two to three foot wave would accompany the storm stillwater tide levels shown. For example, interviews after the 1978 flooding, reported in Reach D that "waves rolled all the way back to Lynnway" (Route 1A). This occurred even though existing walls were nearly equal to the stillwater height of the tides.

Along the Saugus River, the shorefront is generally below the storm stillwater levels and with wind driven waves about two feet, tides would overtop the shorefront below a 100 year (1978) event.

The next section discusses the interior flooding of developed areas. In many cases flood levels beyond seawalls are higher than the tide stillwater levels due to wave action or overtopping. In Lynn high waves drove water back into the business district and residential areas.



LYNN

LOCAL PROTECTION AREA

PLATE 6

TABLE 7

CITY OF LYNN
EXISTING SHOREFRONT AND RUNUP

Reach	Length	Existing Structure Description	Shorefront Top Elev.	Top Elevation of Runup (ft. NGVD) 100 Year	500 Year	SPN
					BROAD SOUND	
A	700	Timber & Rip Rap	10-11	10.3	11.2	12.0±
B	1800	Timber Bulkhead	11.2-11.7		do	
C	1500	Timber & Rip Rap	10.3-11.2		do	
D	3220	Walls	9.8-12.1		do	
E	1100	Rip Rap	8-10		do	
F	1400	Rip Rap/Walls	8-9		do	
G	900	Rip Rap/Walls	8-16		do	
H	800	Ground	10-14		do	
I	2100	Wall	15-17		do	
				SAUGUS RIVER TIDE LEVELS		
J	2500	Ground	8-10	10.6	11.3	12.1±
K	1100	Walls/Grd	9-10		do	
L	1450	Grd/Walls	9-10		do	
M	900	Ground	8-10	10.7	11.5	12.3±
N	1100	Ground	10-16		do	
O	2800	Grd/Walls	7-10		do	
P	1900	Ground	8-10		do	
Q	450	Ground	12-20		do	
R	700	Ground	10-14		do	

Total Value of Flood Plain

The total value of the SPN Floodplain is approximated by determining the value of residential and nonresidential properties. There are about 4040 residential buildings with an average market value of $150,000 and contents (including automobiles) valued at another 50%, or a total value of residential property at $225,000 per building, or $909 million or about $1 billion invested in residential properties.

Nonresidential property (Commercial, Industrial and Public) is based on commercial property which has an average fair market value estimated at $1.3 million per acre and assumed value of contents, equipment and supplies of equal value, or $2.6 million per acre. The total nonresidential investment is approximated at $1.5 billion for 576 acres, (excluding the Town Line and Linden Brook Upper Saugus River and Shute Brook areas).

The total investment in the SPN floodplain would therefore exceed the total value of residential ($1 b) and nonresidential ($1.5 b) properties, or $2.5 billion, if roads, utilities and all areas were included.

Historical Flood Damages and FIA Policies

Information on historical flood damages was found for two events in the study area, the February 19,1972 (a 10-year storm tide), and the February 6-7, 1978 (100-year storm tide).

1972 - The Boston Globe (22 Feb 72) stated that the State Civil Defense Director reported damages in Revere were $5 million and were expected to "mount even higher" and more than 700 Revere homes were evacuated as waves crashed inland. At the 1988 price level (88 P.L.) the 1972 damage value would be $13 million. This compares fairly closely for a 10 year event in Revere shown in the Economic Appendix Table 50 as $10.2 million, with flooding first floors of 545 residential and 46 commercial buildings (Table 48 and 49). These tables excluded Roughans Point in Revere which is outside the study area and has 10 year damages of about $2 million to 231 buildings.

1978 - A report entitled Blizzard of '78 Coastal Storm Damage Study was prepared by the New England Division Corps of Engineers. Damage information was collected from agencies and communities for publishing in the February 1979 report. As stated in the Preface, ".. even six months after the storm, much of the information that was requested was unavailable because it was "too soon." In many cases, data which was collected and reported herein was considered "Preliminary" by the reporting agency..." Information was only reported for two communities in the study area, Lynn and Revere.

In Lynn for example, only 18 homes and 5 businesses were included with reported property losses of $200,000 ($350K @ '88 P.L.) and $10,000,000 ($17 Mill. @ '88 P.L.), respectively. The reported information for Lynn was incomplete and the source could not be located. Detailed damage surveys and extensive interviews throughout the floodplain, however, revealed (Economics Appendix) widespread flooding and damages for about 341 residential and over 162 commercial and industrial buildings with damages estimated at $11 million and $55 million ('88 P.L.), respectively.

In Revere, however, part of the information reported was more in line with the results of detailed investigations. The "Blizzard of '78" document reported 1239 houses and only 6 businesses damaged with property losses of $2,000,000 ($3.5 Mill. @ '88 P.L.) and $13,151,450 ($22.7 Mill. @ '88 P.L.), respectively. Detailed investigations showed first floor flooding in the Revere study area to 868 residential and 133 nonresidential buildings with losses of $22.2 million and $10.6 million ('88 P.L.), respectively. In addition at Roughans Point the totals were 301 buildings primarily residential, at about $10 million. Therefore, the detailed investigations confirmed about 1200 homes had serious damages with first floor flooding, although damages would by higher than provided in the "Blizzard of '78" report and a more complete inventory of nonresidential damages was accomplished. This report also includes losses for developments and improvements accomplished since 1978.

Additional evidence of the flooding problem in Revere is provided by the Flood Insurance Administration data on claims paid in Revere. Claims paid from 1974 to 1980 follows:

Claims Paid by FIA at Revere

Year	No. of Policies	Claims Paid ($1000)	Year	No. of Policies	Claims Paid ($1000)
1974	54	43.7	1982	109	143.3
1975	1	0.5	1983	12	31.8
1976	7	7.4	1984	11	18.4
1977	18	30.3	1985	18	14.5
1978	281	2526.7	1986	1	4.0
1979	640	1314.7	1987	54	195.6
1980	7	7.9	1988	2	1.2
1981	19	9.3			

This table shows that Revere as a whole suffers a substantial amount of damage on a fairly regular basis. The figures can be considered conservative since it fails to account for the flood insurance deductible and because several categories of losses (grounds, nonphysical, motor vehicles, etc.) are not claimable under the flood insurance program. Also, in 1978 only about one-fifth of the 1300 structures flooded in Revere were covered by flood insurance. Also many of the commercial and industrial buildings carry insurance other than FIA.

By 1986, Revere had over 1000 policies subsidized by the National Flood Insurance Program, as shown below. The number of policies for each community largely reflects the frequency and severity of frequent flooding. Revere as indicated in the table has a general start of damage in Roughans Point and behind Revere beach, especially, at Elevation 4 ft. NGVD, which is below mean high tide (EL. 5.0) and which affects drainage and frequent ponding of interior runoff for a large number of buildings, indicated by the 10 year floodplain. Flooding from both interior runoff and frequent storm waves overtopping their seawalls is a yearly incentive to take out flood insurance. While buildings in Saugus, Lynn and Malden are higher in the floodplain with fewer residential buildings and a lower yearly frequency and depth of flooding attributable to coastal or interior runoff flooding.

Community	Residential Buildings w/first floor Flooding in 10-year Floodplain	General start of Flooding Behind Shorefront	National Flood Insurance Program			
			Total Policies 1986	Total Policies 1989	Written Premium 1986 ($1000)	Coverage ($Million) 1989
Revere	775	EL. 3-4	1,008	814	$241.7	$42 M
Saugus	201	EL. 6	155	117	37.9	7 M
Malden	ND	EL. 7±	37	55	9.1	3 M
Lynn	151	EL. 8	17	17	29.8	7 M
		Total	1,217	1,062	$318.5	$59 M

FLOOD INTERVIEWS

The following section describes the results of over 500 flood interviews and location and elevations of high water marks by geographic areas.

REVERE BEACH BACKSHORE AREA

The Revere Beach Backshore area includes 1200 residential, commercial, and public buildings in the floodplain. It includes those flood prone areas in Revere located directly behind Revere Beach where flooding is caused by tidal overtopping of existing Revere Beach seawalls, tidal surges up the Pines River and overland flow, runoff from rainfall and snowmelt, and backup of Sales Creek and other drainage systems. The area is divided into flood zones 1 to 5 (see Plates Q-1A and 1B) and the perimeter of the area into reaches A to K. In 1978 a reported 3000 people were evacuated to the Revere High School as water flooded up to depths of seven feet around homes and businesses.

Zone 1 - includes residential, commercial and public buildings in the Crescent Beach and Garfield School area. In the February 1978 flood the area received tide waters from the backup of Sales Creek in Reach K when tides overtopped Bennington Street and flooded Suffolk Downs. Along the shorefront, tides overtopped at Roughans Point, Eliot Circle and the Revere Beach (Reach B) seawall north of Beach Street. Saltwater flowed into area from several directions causing flooding up to three feet deep around buildings.

Zone 2 - The Ocean Avenue (2A) and Wonderland Park (2B) areas are flooded by overtopping along 4000 feet of the Revere Beach seawall from Beach to Revere Street. In 1978 flood waters were 7.0 and 5.7 feet deep in each area, respectively. The MBTA blue lines was out of service for six weeks. Considerable damage resulted to commercial, public and residential buildings, including the Historic MDC Police Station, MDC Maintenance Garage and other facilities. Roofs and benches to the historic pavilions built in the late 1890's were also damaged. In January 1979 and January 1987 the areas were flooded with several feet of water. The MDC reported the seawalls are overtopped about seven times a year requiring cleanup of sand, cobbles and debris from streets and drains.

Zone 3 - The area was believed to have flooded in 1978 from a tide gate that was purposely left open for flushing wetlands in the area. The area includes the Towle Industry Building, Revere High School and other residential and commercial buildings. Flood waters in the Wonderland Park area rose to the top of the railroad embankment, which separates 2 and 3; however, no water was observed flowing into zone 3. Homes were flooded in Zone 3A from three feet of ponding water in 1978.

Zone 4 - The area around Oak Island, especially Kelley,s Meadow (4A) was flooded in 1978 from the ponding of six feet of water, which remained for up to a week due to a snow blocked drain at North Shore Road, Route 1A. Tide waters which overtopped the Reach "B" seawall by the Police

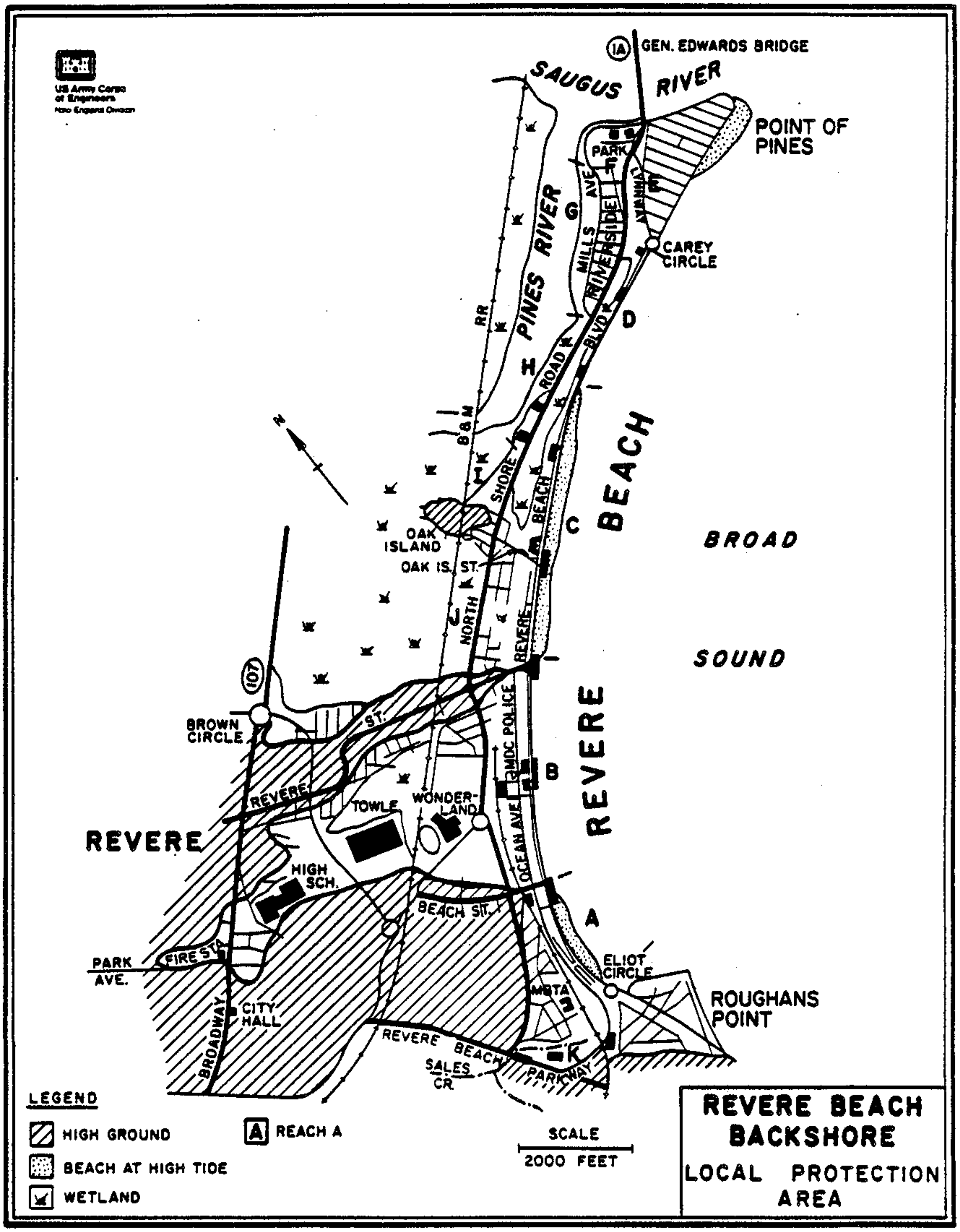
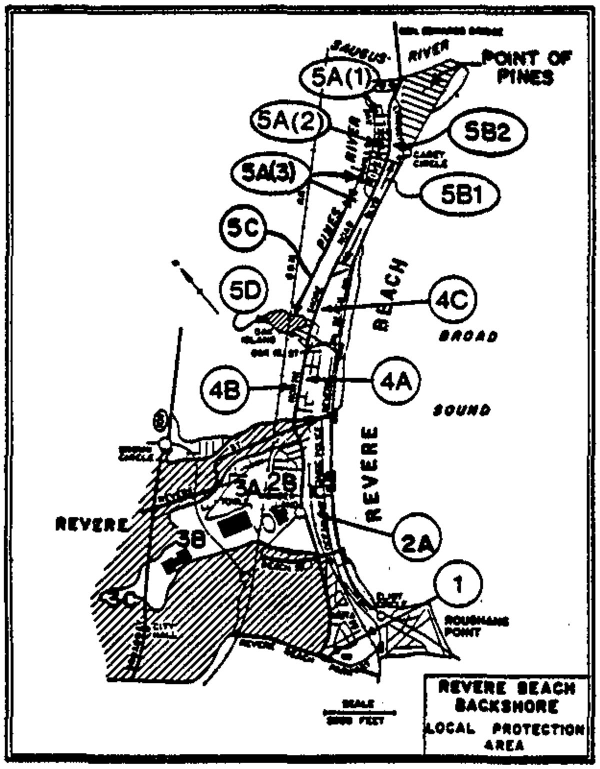

US Army Corps of Engineers
New England Division
GEN. EDWARDS BRIDGE
1A
SAUGUS RIVER
POINT OF PINES
PARK
AVE
MILLS
RIVERSIDE
PINES RIVER
CAREY CIRCLE
RR
B & M
BLVD
ROAD
SHORE
BEACH
NORTH
REVERE
OAK ISLAND
OAK IS. ST.
BEACH
BROAD
SOUND
REVERE
107
BROWN CIRCLE
ST.
REVERE
TOWLE
WONDER-LAND
MDC POLICE
OCEAN AVE
REVERE
HIGH SCH.
BEACH ST.
PARK AVE.
FIRE STA.
CITY HALL
BROADWAY
REVERE BEACH
PARKWAY
SALES CR.
MBTA
ELIOT CIRCLE
ROUGHANS POINT
A
B
C
D
E
F
G
H
J
K
N
LEGEND
HIGH GROUND
BEACH AT HIGH TIDE
WETLAND
A REACH A
SCALE
2000 FEET
REVERE BEACH BACKSHORE
LOCAL PROTECTION AREA

PLATE Q-1A

FLOOD ZONE	AREA	NUMBER OF HWM's USED	RANGE IN HWM's USED ELEVATION (FT. NGVD)	AVERAGE OF 1978 HWM ELEVATIONS (FT. NGVD)	APPROX. DEPTH OF WATER (FEET)
1	Crescent Beach	14	5.5 - 9.5	7.0	3.0
2B	Wonderland Park	20	8.4 - 10.3	9.2	5.7
2A	Ocean Avenue	3	11.4 - 11.7	11.5	7.0
3A	Towle	4	6.0 - 7.0	6.4	2.9
4A	Kelley's Meadow	21	7.4 - 9.5	8.3	5.7
4B	B & M Railroad	4	6.0 - 7.1	6.5	4.4
4C	Revere House	10	7.0 - 9.5	7.7	4.4
5A(1)	Riverside, North end	18	9 - 11	10.2	3.7
5A(2)	Riverside, Central	26	8.8 - 9.5	9±	0.7
5A(3) & 5C	Riverside, South end & No. Shore Rd.	10	9.8 - 12.5	11.0	2.4
5B1	Revere Bch. Blvd. (Back of Homes)	11	10.0 - 12.5	11.1	6.6
5D	Outer Oak Island	6	7.5 - 8.8	8.3	2.3



NOTE: Flood information and High Water Mark interviews were conducted by the Corps in 1982 and 1983. Elevations were determined from spot elevations on topographical maps, scale 1 inch = 100 ft. and two foot contours.

JULY 1986

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

REVERE BEACH BACKSHORE

1978 HIGH WATER MARKS

US Army Corps of Engineers
New England Division

PLATE Q-1B

Station flowed along the county ditch under Revere Street into the Meadows. Most people in the area were evacuated with the help of MDC vehicles and others. Flood waters then flowed over North Shore Road into area 4B which was partially protected from the Pines River by a tide gate in the B&M railroad embankment, Reach "J". However, B&M officials reported ice on the tracks which probably floated there when the Pines River overtopped the embankment at the peak of the flood.

The Revere House, area 4C, is believed to have been partially protected in 1978 by barriers of plowed snow reported along Route 1A, along Oak Island Street with snow drifts over 10 feet high and along Revere Beach Boulevard, since very little water entered this area. However, in 1987 water from the Pines River flowed in freely by overtopping Route 1A. Areas 4A and 4B were also flooded in 1987 from overtopping of the Reach "B" seawall by the Police Station and railroad embankment in Reach "J".

Zone 5 - includes homes in Riverside (5A), homes along Revere Beach Boulevard (5B), homes and businesses along the Pines River (5C) and the outer edge of Oak Island (5D). Rising tides backing up the Pines River in 1978 overtopped the banks into these developed areas causing severe flooding. Minor flooding occurred in the central area in Riverside 5A(2) which was partially protected by snowbanks along Mills Avenue and Route 1A. This may also have occurred for areas of Oak Island. Overtopping of the Revere Beach seawalls in reaches C5B and D and Carey Circle also contributed to the flooding in these areas. Flood water in 1978 was up to 6.6 feet deep behind homes on the Boulevard. Riverside properties were recently flooded on December 3 & 31, 1986 and January 2, 1987. Although no flood levels are shown for Zone 5B2 on Plate Q-1B, residents reported the water was several feet deep and ice was floating toward Route 1A.

POINT OF PINES AREA

The Point of Pines Area includes 370 buildings, just about all homes or duplexes, and was one of the hardest hit areas in Revere during the 1978 flood. Depths of water around many homes reached four feet while residents were waiting to be evacuated in freezing cold weather and no electricity. Flood waters reportedly overtopped nearly their entire length of shoreline, almost a mile along Broad Sound and the Saugus River. In the vicinity of the sand dunes water reportedly came through a breached sectin at the south end of the dunes during the peak of the tides. High water marks from interviews revealed waters reached an average elevation of 12 ft. NGVD at the south end from wave overtopping and EL.10 at the northern lower end where water eventually flowed out by the Yacht Club.

Overtopping at the Revere Beach northern traffic circle, Carey Circle, flowed in many directions, and contributed to flooding in Point of Pines. Residents near the circle reported water splashed above the seawall to heights of 30 feet. The area was also flooded in 1972, 1979 and 1987.

Wave heights along the shorefront of Point of Pines, as well as, at the mouth of the Saugus River and in Lynn Harbor are considerably lower than the 9 to 10 foot storm waves fronting Revere Beach. As shown on Plate Q-1C these areas are partially protected by Nahant, Little Nahant and the causeway or roadway behind Nahant Beach. The transition of lower waves which refract around Nahant occurs at Point of Pines. The lower waves contribute to the stability of the dunes and building up of the beach in this area. Also the predominant movement of sand along Revere Beach is toward Point of Pines which nourishes the beach and dunes. The dunes and beach were apparently high enough to prevent overtopping in 1978 except at the southern end where the dunes are the narrowest with a lower beach and partially breached by foot paths.

NORTHGATE AREA

The Northgate Area includes about 180 homes and businesses along the edge of the Pines River marsh where flooding occurred in 1978, 1979, and 1987. Flood waters in 1978 were up to 3 feet deep around homes on Emmanuel, Naples, Milan and other streets east of Brown Circle (see Plate Q-2A). The commercial areas to the west are on higher ground and therefore received minor flooding in 1978.

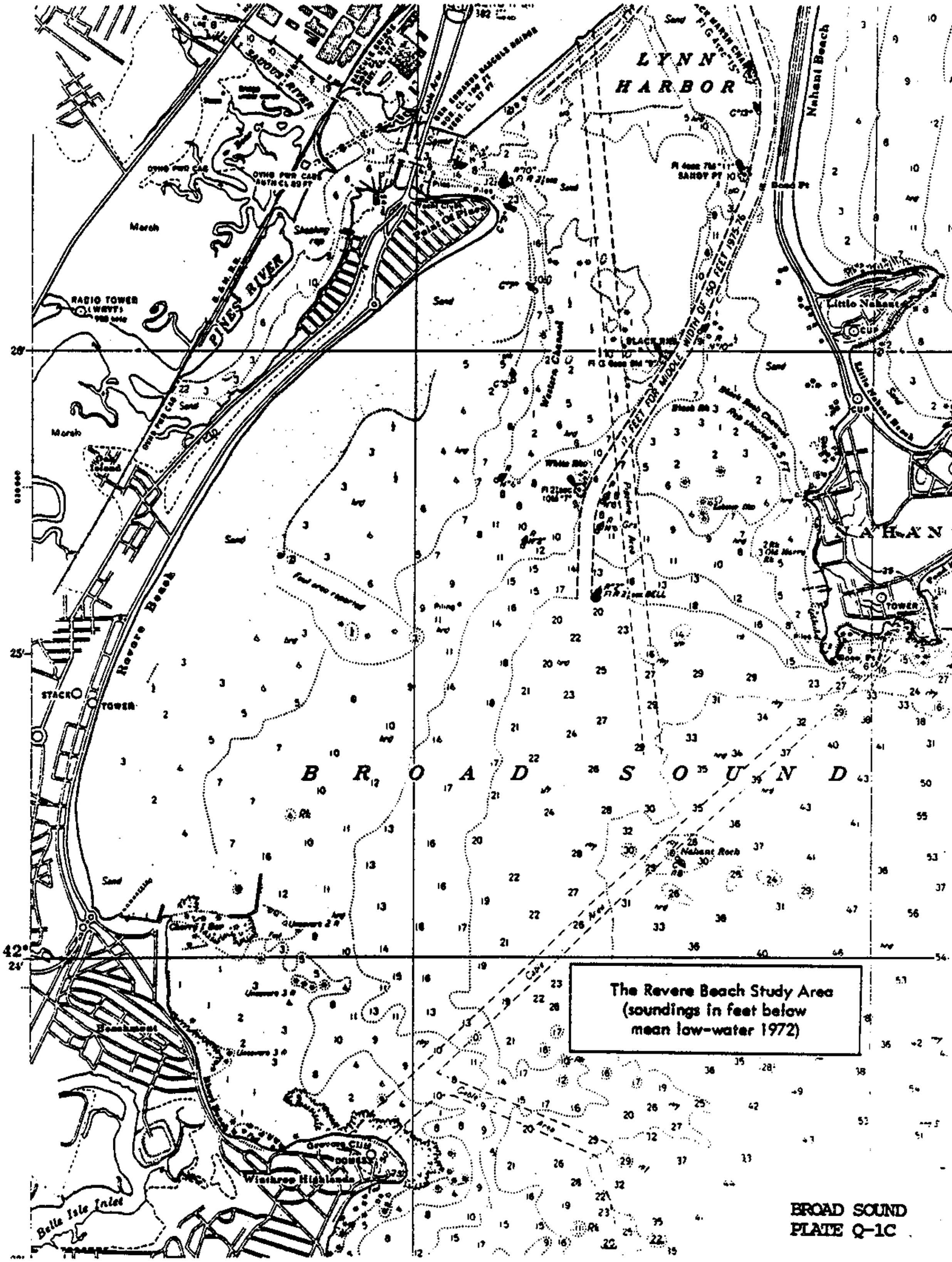
TOWN LINE BROOK AREA

The Town Line and Linden Brook Area includes watersheds in Revere and Malden. See Plate Q-2B. Flooding occurred in 1978 and 1979, and reached the top of the banks of Town Line Brook in 1987. The MDC proposed flood control plan for the area includes a pumping station, interior drainage improvements and shorefront improvements to prevent tides from overtopping the area. About 1000 homes and businesses are in the flood plain. The only work the Corps has done in this area includes a limited number of interviews and estimating the cost and environmental impacts of shorefront improvements. The existing shorefront includes an MDC dike which prevents normal high tides from entering the watershed. The dike has eroded to the point where coastal storm tides overtop the dike. Existing MDC tide gates at the outlet to Town Line Brook prevent normal high tides from backing up the brook. The area's major flooding problems occur during runoff in the watershed accompanied by high tide which prevents the area from draining. Tidal overtopping can occur over U.S. Route 1 (Reach B) and the railroad embankment and dike (Reach C). Tides also backup an existing culvert in Reach A.

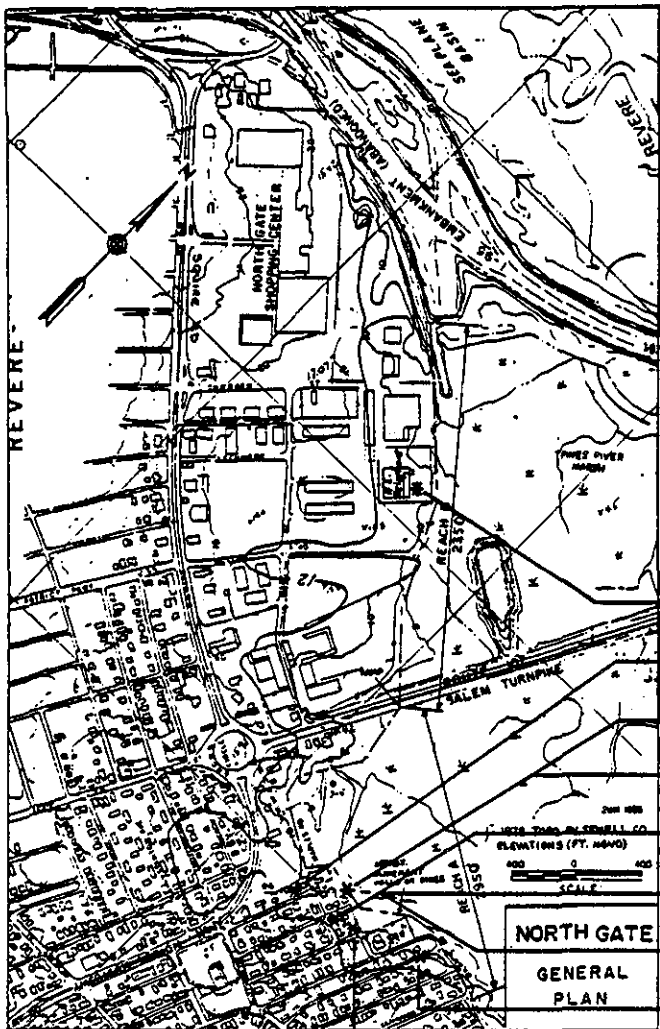
EAST SAUGUS AREA

East Saugus is primarily a residential area of 600 buildings. Commercial property is primarily devoted to fishing and marinas along the Saugus River. In 1978 about 400 homes were flooded and 300 people evacuated by volunteers and town officials. High water marks and depths of flooding are shown on Plate Q-3.

Zone 1 includes most of East Saugus' commercial property located between the Saugus River and Ballard Street. The area was flooded up to 3.5 feet deep in 1978. The area was partially flooded in 1987 and Ballard Street was overtopped.



BROAD SOUND
PLATE Q-1C



HWM NO.	YR.	APPROX. HIGH WATER ELEV. (FT. NGVD)	WATER DEPTH (FEET)
NS-1	'78	11.1	–
BC-2	'78	10.6	1.0
BC-3(1)	'79	10.1	0.8
BC-3(3)	'78	10.8	1.5
BC-3(2)	'78	11.3	–
BC-4	'78	11.3	–
BC-9	'78	11.3	–
BC-6	'78	10.5	–
BC-5	'78	9.9	0.5

NOTE: Flood information and High Water Mark interviews were conducted by Vollmer Assoc. and the Corps, and elevations surveyed by the Sewall Co. in 1985 and 1986.

JULY 1986

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

NORTH GATE

HIGH WATER MARKS

US Army Corps of Engineers
New England Division

PLATE Q-2A

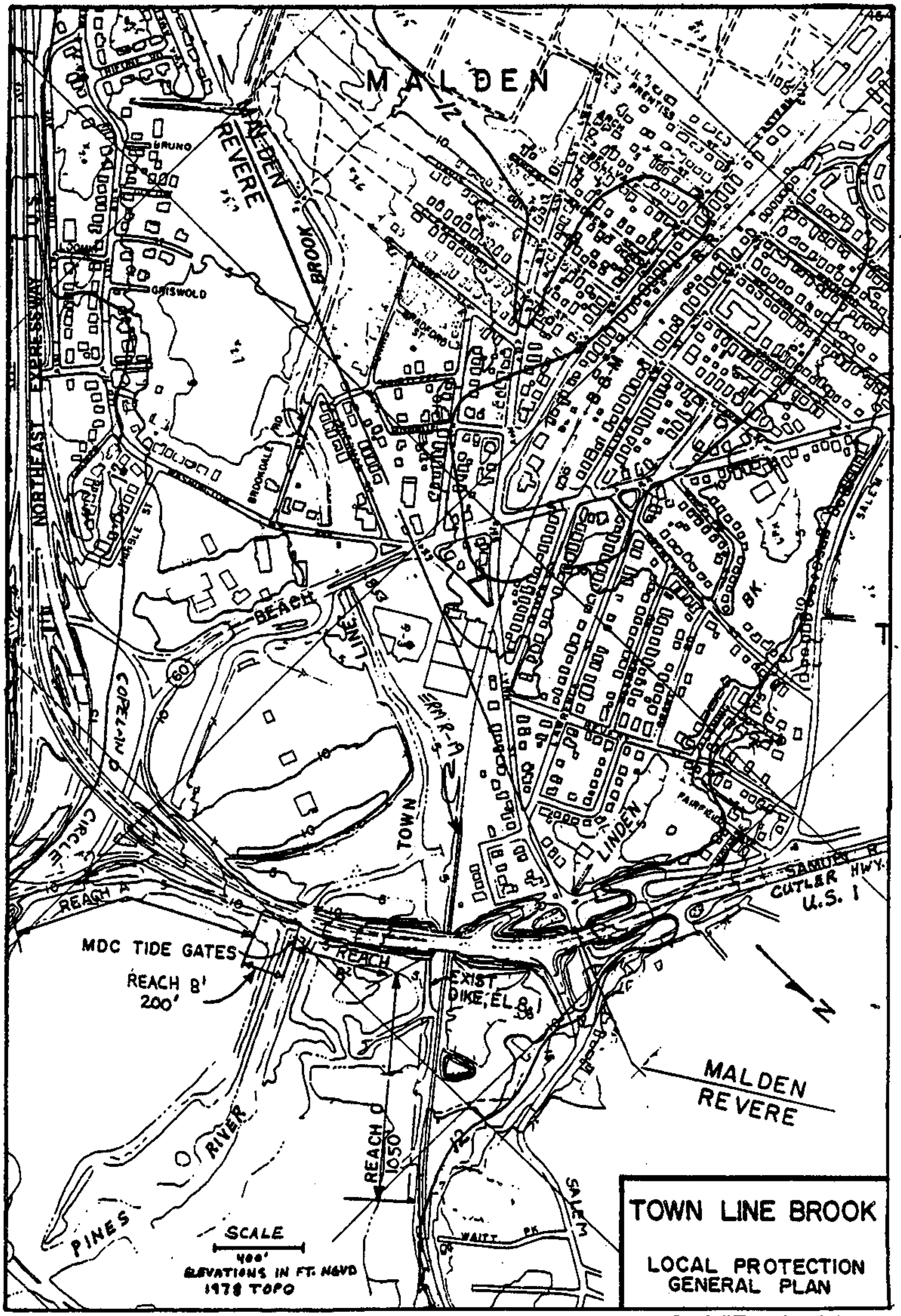

MALDEN
MALDEN
REVERE
BROOK
BRUNO
GRISWOLD
NORTHEAST EXPRESSWAY
U.S.
BROOKDALE RD
BEACH
60
COPELAND
CIRCLE
TOWN
LINE
LINDEN
BK
FAIRFIELD
SALEM
PRENTISS
REACH A
MDC TIDE GATES
REACH B'
200'
REACH
EXIST
DIKE, EL 8.1
SAMUEL R.
CUTLER HWY.
U.S. 1
N
MALDEN
REVERE
RIVER
PINES
REACH C
1050
SALEM
WAITT PK
SCALE
400'
ELEVATIONS IN FT. NGVD
1978 TOPO
TOWN LINE BROOK
LOCAL PROTECTION
GENERAL PLAN

PLATE Q-2B

FLOOD ZONE 3

Saugus Marsh to Bristow St.

BB-5 10.6 OUT 3.0
BB-4 10.6 OUT 3.0
BB-3 10.4 OUT 3.0

FLOOD ZONE 2

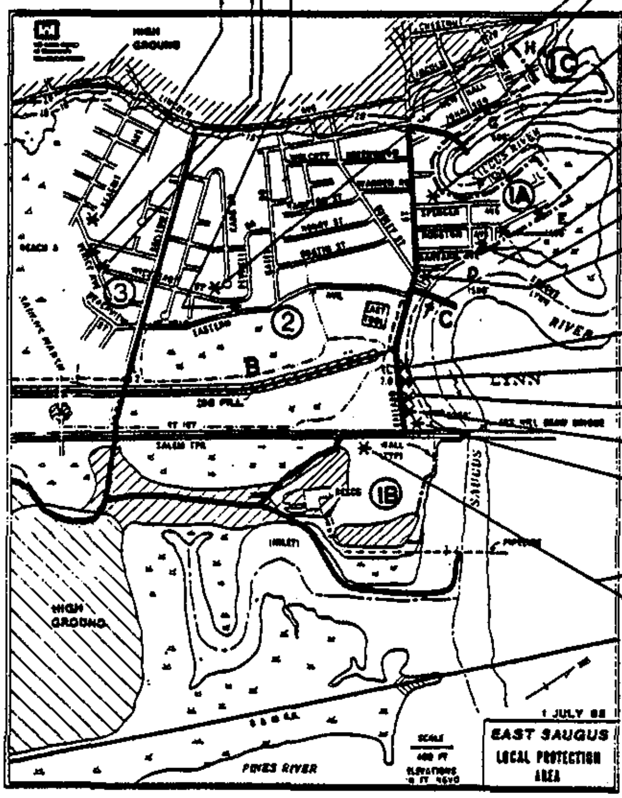
Between Ballard and Bristow Sts.

BB-17(1) 11.0 IN 1.0
BB-15 10.3 IN 0.8

FLOOD ZONE 1

Saugus River to Ballard St.

HWM ID NO. "BB"	WATER ELEV. (FT. NGVD)	OUTSIDE OR INSIDE OF BLDG.	WATER DEPTH (FEET)
48	11.4	OUT	0.1
43	10.4	IN	2.0
40	10.8	OUT	1.8
39	11.5	OUT	1.7
38	11.2	OUT	2.5
31	11.8	OUT	3.5
29	10.8	OUT	3.0
25	10.5	IN	0.1
23	11.6	IN	3.5
22	11.1	IN	3.5
21	10.0	IN	1.3
20	10.4	IN	1.5
17(2)	11.9	IN	3.0



NOTE: Flood information and High Water Mark interviews were conducted by Vollmer Assoc. and elevations surveyed by the Sewall Co. in 1985 and 1986.

US Army Corps of Engineers
New England Division

JULY 1986

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

EAST SAUGUS

1978 HIGH WATER MARKS

PLATE Q-3

Zone 2 includes the Ballard School, Eastern Tool, and homes between Ballard and Bristow Streets. The area was flooded in 1978, 1979 and 1987 when water overtopped Ballard Street and also backed up drainage ditches and flowed overland from the Pines River Marsh. In 1978 flood waters were about five feet deep on Pevwell Drive, based on reported elevations of first floor flooding. Flood waters were about two feet deep in 1979 and 1987.

Zone 3 borders 3300 feet of the Saugus/Pines Marsh. The area floods when tides overtop the bank of the developed area and backs up drainage systems. In 1978 high tides produced flood levels up to three feet deep on Seagrit, Venice and Beachview Streets. Properties on Beachview and Seagrit were also flooded in January 1987. Beachview residents also reported flooding of basements and yards during high tides on December 3 and 31, 1986.

UPPER SAUGUS RIVER AREA

This area includes about 300 homes and businesses along the Upper Saugus River and Shute Brook areas in Saugus, upstream of Lincoln Avenue (see Plate O-4). Flooding along the Saugus River and Shute Brook, downstream of Central Street is primarily affected by tide levels. Above Central Street, the Shute Brook area floods primarily by runoff in the brook which backs up during high tides.

Flooding in 1978 was up to five feet deep on property at the lower end of Shute Brook. Upstream of Central Street high water marks show higher water elevations due to the restricted flows. Damage surveys have not been conducted in these areas.

UPPER SAUGUS RIVER AND SHUTE BROOK

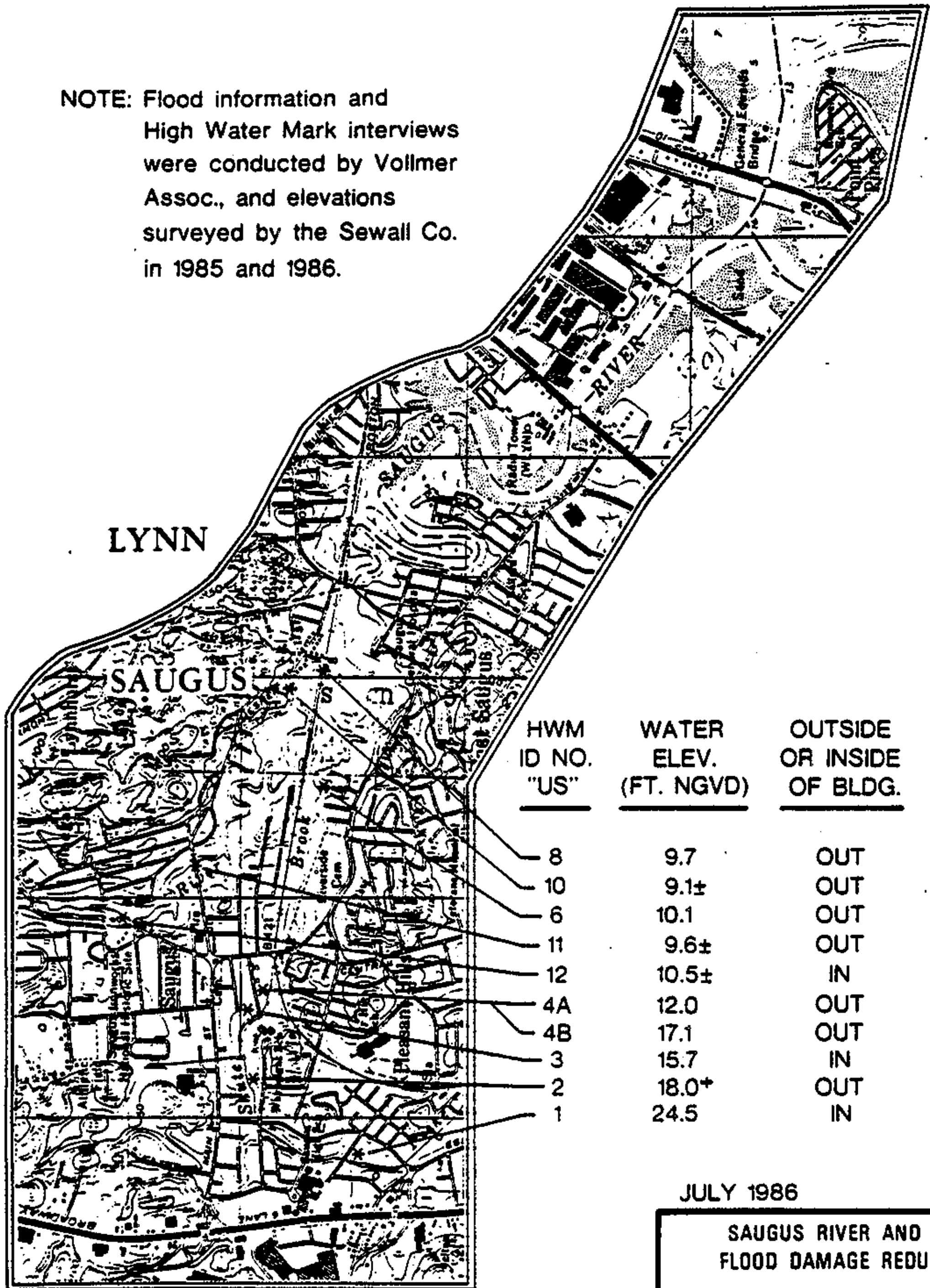
Reconnaissance studies for the Upper Saugus River and Shute Brook areas above Lincoln Street Bridge were conducted to determine potential flooding which might be partially alleviated by a Regional Floodgate Plan. In 1978 high water marks ranged from EL. 9.1 to 10.5 in the tidal portion of the river and brook to a high of EL. 18 in the higher part of the brook. See Plate O-4.

A cursory review of flood levels in the upper portion of Shute Brook and the Saugus River reported in the Flood Insurance Report revealed flood stages could be up to several feet higher if high interior runoff is accompanied by high coastal storm tides. No additional work was accomplished by the study. The study however, recognizes that the Regional Floodgate Plan would reduce flood stages in these areas where tides retard runoff from the watershed.

LYNN AREA

The city of Lynn coastal floodplain which includes about 1400 residential, commercial, educational, industrial and public buildings is divided into five zones. Plate O-5 summarized many of the high water marks obtained during interviews.

NOTE: Flood information and High Water Mark interviews were conducted by Vollmer Assoc., and elevations surveyed by the Sewall Co. in 1985 and 1986.



HWM ID NO. "US"	WATER ELEV. (FT. NGVD)	OUTSIDE OR INSIDE OF BLDG.	WATER DEPTH (FEET)	YEAR
8	9.7	OUT		1978
10	9.1±	OUT	1.0	1978
6	10.1	OUT	5.0	1978
11	9.6±	OUT		1978
12	10.5±	IN	0.5	1978
4A	12.0	OUT	0.6	1984
4B	17.1	OUT	5.8	1954
3	15.7	IN		1978
2	18.0+	OUT		1978
1	24.5	IN	5.0	1954

JULY 1986

US Army Corps of Engineers
New England Division

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

UPPER SAUGUS RIVER

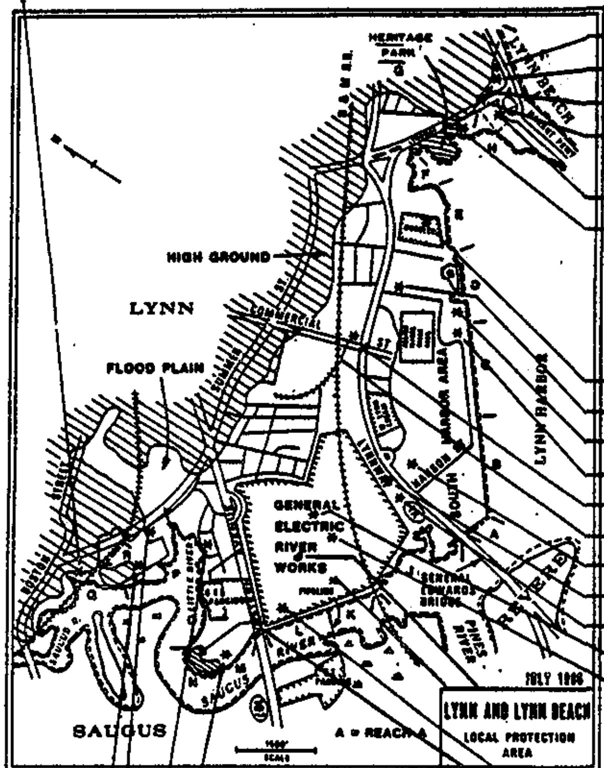
HIGH WATER MARKS

PLATE Q-4

FLOOD ZONE 4

SAUGUS RIVER B & M RR TO BOSTON ST.

SR-12	9.0	OUT	–	'78



FLOOD ZONE 5

LYNN BEACH TO TUDOR ST.

HWM ID NO.	WATER ELEV. (FT NGVD)	OUTSIDE OR INSIDE OF BLDG.	WATER DEPTH (FEET)	YEAR
LB-2	12.8	IN	5.5	'78
3	12.5	OUT	2.0	'78
4	12.2	OUT	2.5	'78
1A	12.5	IN	2.8	'78
1B	11.1	IN	1.5	'79
7	11.2	OUT	1.0	'78
HS-1A	12.9	IN	2.0	'78
1B	11.0	IN	0.1	'79

FLOOD ZONE 1

LYNN HARBOR TO SUMMER ST.

HS-5	11.5+	OUT	4.0+	'78
6	12.4	OUT	2.5	'78
7	13.2	OUT	3.0	'78
16	12.5	OUT	2.0	'78
9A	10.1	OUT	–	'79
9B	11.1	OUT	2.0	'78
12	12.8	IN	0.1	'78
13	11.5	IN	0.1	'78
14	13.4	IN	0.2	'78

FLOOD ZONE 2

SAUGUS RIVER GENERAL ELECTRIC

GE-8	11.2	IN	0.7	'78
6	11.0	IN	0.5	'78
9	10.9*	OUT	2.0	'78
11	11.5*	OUT	1.5	'78
2	11.6	IN	0.1	'78
1	11.1	OUT	2.8	'78
10	11.3	OUT	3.0	'78

FLOOD ZONE 3

SAUGUS RIVER (LITTLE RIVER) WESTERN AVE. TO SUMMER ST.

SR-16	10.6	OUT	1.5	'78
15A	9.6	IN	1.3	'78
15B	9.3	IN	1.0	'79
2A	10.9	OUT	2.0	'78
2B	10.9	OUT	4.0	'78
5	10.0	IN	0.5	'78

SEPT. 1986

NOTE: Flood information and High Water Mark interviews were conducted by Vollmer Assoc. and the Corps, and elevations surveyed by the Sewall Co. in 1985 and 1986.

US Army Corps of Engineers
New England Division

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

LYNN

HIGH WATER MARKS

PLATE Q-5

Zone 1 - includes the commercial and industrial district along Lynnway (Route 1A) with some residential areas. Among the industrial, commercial and public buildings in the floodplain are the Philips Lighting/Norelco complex, West Lynn Creamery, the Regional Wastewater Treatment Facility and North Shore Community College. Route 1A which is owned and maintained by the Metropolitan District Commission serves about 28,000 northshore commuters a day. It is a direct access route for many of Lynn's businesses and industries and was flooded in 1978 and 1979. In the Blizzard of 1978 tides overtopped all along the Lynn Harbor shorefront flooding businesses along Lynnway with water depths up to four feet.

In 1987 flood waters again overtopped all along Lynn Harbor causing erosion behind bulkheads and flooding commercial property to depths of several feet. Frequent high tides during the year cause saltwater to pond around parking areas and unloading zones, delaying commercial activities. Storms have also damaged many boats moored in Lynn Harbor.

Drainage problems throughout the area also plague many businesses when tides are high. The area's street drain directly into the tidal Saugus River or Lynn Harbor. High tides prevent the drainage systems from draining properly. During severe flood conditions the tides back up through the drains out of the catch basins and into the streets, adding to the depth of stormwater already ponding in the streets.

Extensive development and urban renewal is on going in the area with several high rise condominiums constructed and others planned. The most ambitious development is an $800 million venture in the Lynn South Harbor Area by Transcontinental Development Corporation. Plans include hotel, office, retail, condominium and marina facilities.

Zone 2 includes the General Electric River Works complex with 266 buildings and a work force of 8 to 12,000 with an annual payroll reaching $450 million. Steam turbine generators and jet engines are produced for the Defense Department among other military and civil contracts amounting to $2 to $3 billion a year. Normally, the only problems experienced are the flooding of parking areas which require employees to move their cars. In 1978 the complex was shut down at the start of the Blizzard in advance of high tides, which probably prevented considerable damage. Only a few buildings were reported flooded with 6 to 8 inches of water, while outside depths of several feet were reported at several locations. Western Avenue, Route 107, which borders the complex to the west was also flooded with about three feet of water in 1978. Also this heavily travelled highway, which leads to the heart of the city, was shut down when flooded in January 1987.

A gaging station, installed at the Route 107 bridge across the Saugus River, provided valuable tide data for the 1987 flood. The tide gage confirmed information previously developed by the modeling for this event.

Zones 3 and 4 - are also flooded from the Saugus River and the backing up of drainage systems. Considerable damage occurred in homes, businesses and industries in 1978 and 1979. In 1987 residential and commercial properties in the vicinity of Summer Street were again flooded.

Zone 5 - is located behind Lynn Beach and includes residential and commercial buildings. The 2100 foot long seawall along the eroded Lynn Beach is overtopped during coastal storms. In 1978 depths up to 5.5 feet were reported in residential buildings and many people were evacuated. In 1979 and 1987 saltwater reached almost two feet deep in some areas, including the rotary to Nahant. The area is also exposed to high tides in Lynn Harbor. Deterioration is evident on the Lynn Beach seawall due to the daily pounding of waves on its vertical surface. The wall which is owned by the Metropolitan District Commission has been raised and repaired on several occasions.

FUTURE DEVELOPMENTS WITHOUT A FEDERAL PROJECT

This section provides supporting documentation for the most likely future condition in the study area <u>without</u> a Federal project. Future development in the study area is explained in the Main Report. Improvements are shown on the referenced figures.

A "Revere Connector" highway across or, more likely, bordering the estuary from U.S. Route 1 to Rt. 1A. (Figure 1).

Extension of the MBTA (Massachusetts Bay Transportation Authority) Blue Line adjacent to the existing B&M Commuter Line from Revere to Lynn. (Figure 1).

Development of the MBTA Commuter Rail Station and 1,000 space parking on the Saugus landfill off Rt. 107. (Figure 1).

The construction of the Saugus River Navigation Project, which would designate the Saugus River as a Federal Navigation Channel and, include dredging and maintenance of the channel and mooring areas. (Figure 6).

The restoration of Revere Beach with sand from the abandoned I-95 embankment, resulting in improved stabilization of Revere Beach seawalls and reduction in overtopping. (Figure 2).

The development of a State linear park along the remaining I-95 land. (Figure 1).

Construction of the Roughans Point, Revere, Flood Damage Reduction Project. (Figure 3)

Private or state dredging, for navigation, of the lower Pines River, (Figure 6).

Eventual development of the complete Master Plan for the Revere Beach Reservation including the linear parkland, recreation facilities, pavilion restoration, drainage improvements and other features. (Figure 4 & 5).

Construction of the MDC Town Line and Linden Brook Flood Control Project. (Figure 6).

Construction of a sewer project to reduce or eliminate the combined sewer overflow from Lynn's Strawberry Brook into the Saugus River. (Figure 6).

Continued maintenance, repairs and future raising (due to sea level rise) of nearly 30 miles of existing non-Federal flood and erosion control shorefront structures along the Saugus and Pines Rivers and Broad Sound. (Figure 7).

Moderate growth in recreational navigation is expected to continue on Construction of Saugus' Lobstermens Landing along the Saugus River and Potential Marinas or expansions at the mouth of the Saugus River. (Figure 6).

Development of the Lynn South Harbor area with condominiums, retail, hotel and office buildings, marina facilities and shorefront structures. (Figure 6).

Development over the next five years of the Harborside Landing Condominium Project in Lynn Harbor adjacent to Heritage Park. Includes shorefront protection to EL. 13 ft. (maximum EL. 18) NGVD. (Figure 8).

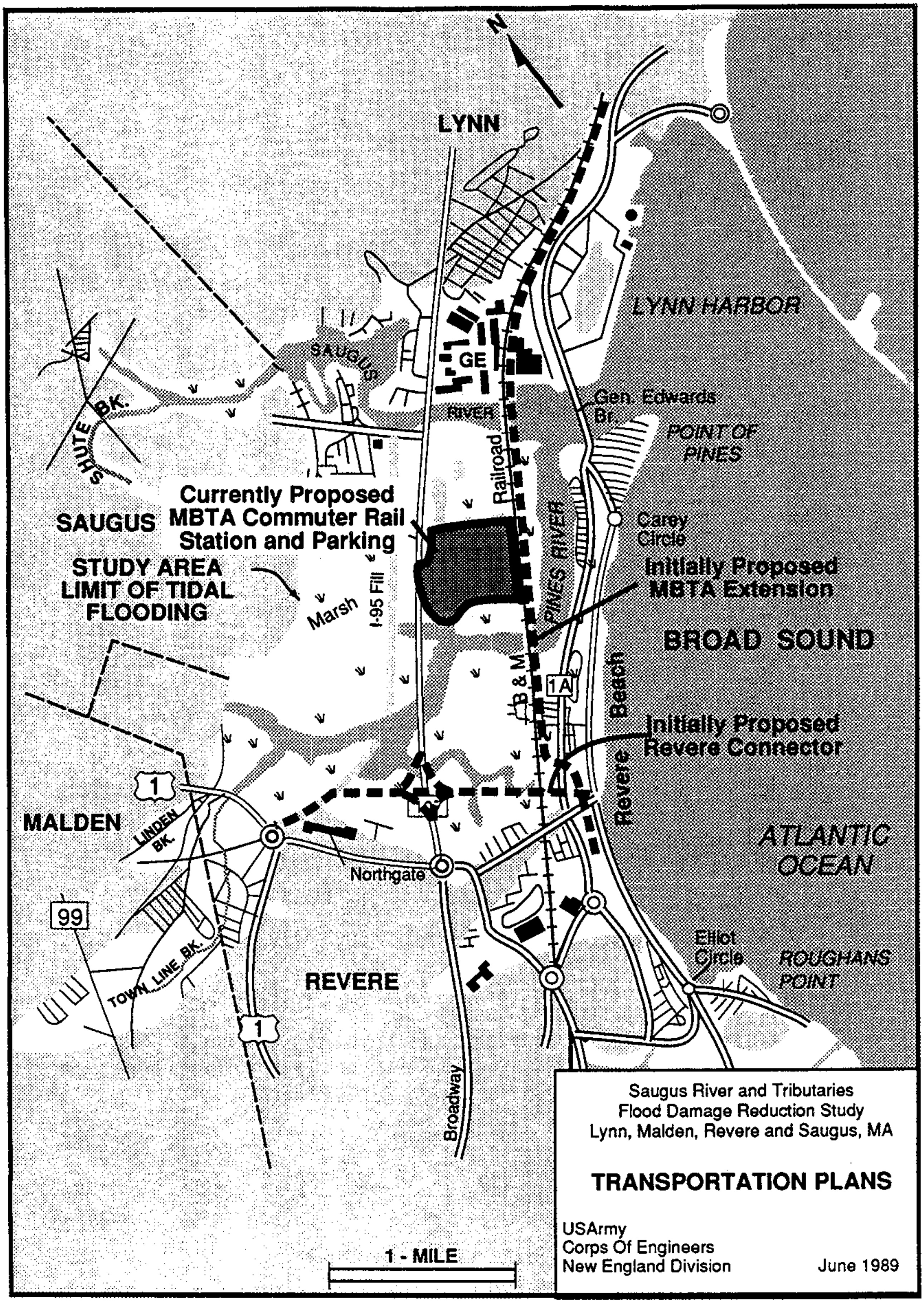
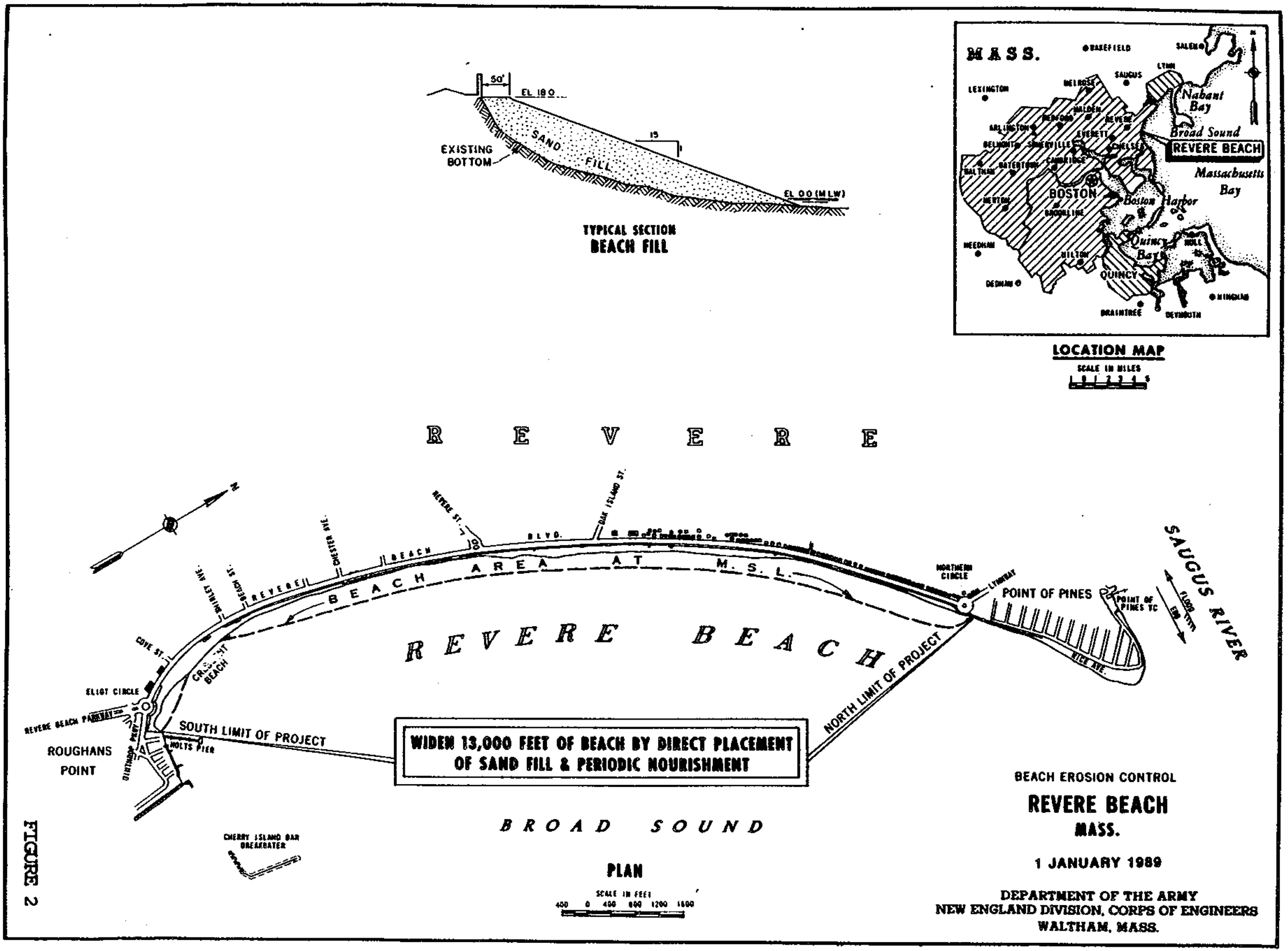
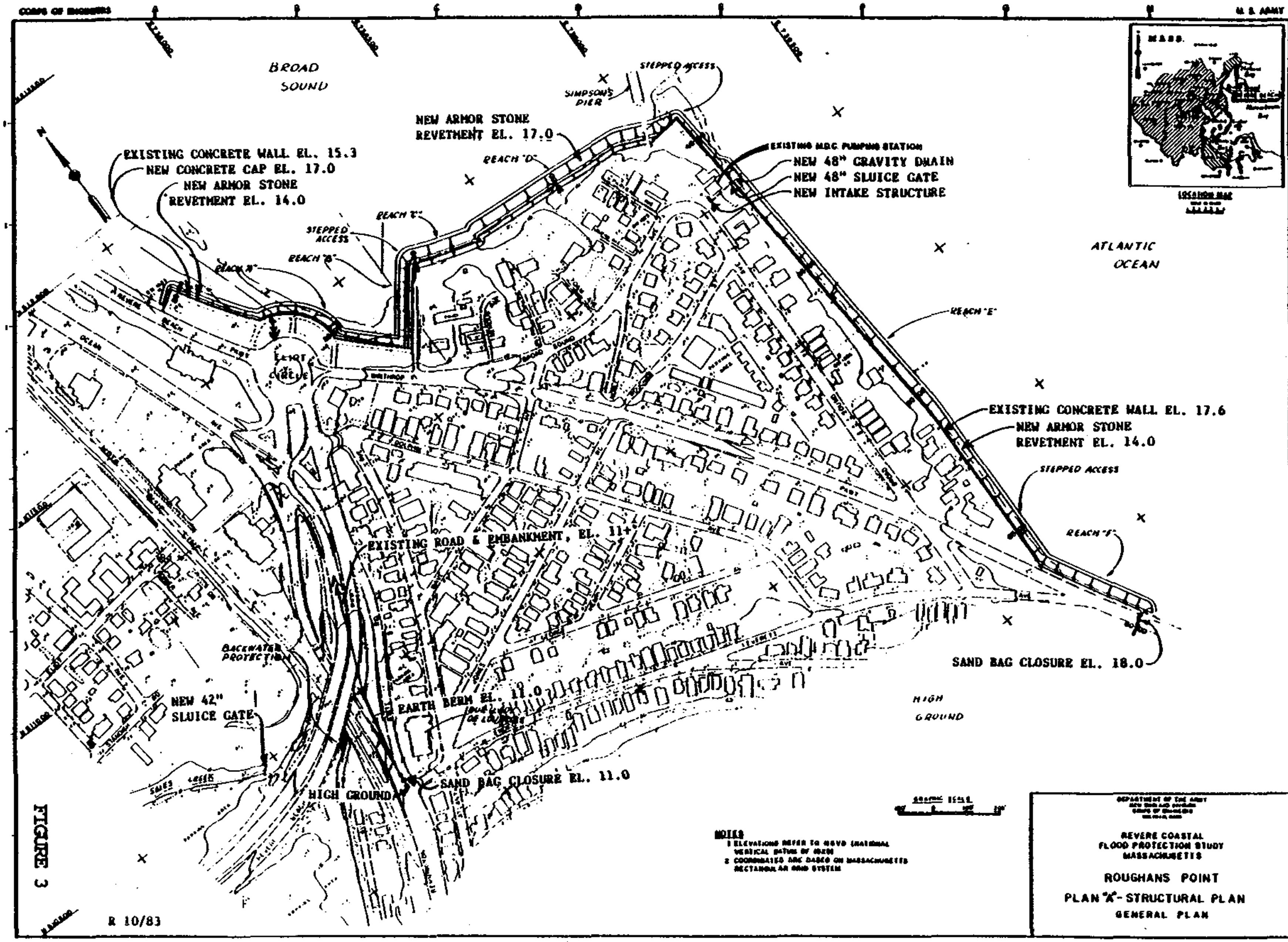

N
LYNN
LYNN HARBOR
SAUGUS
RIVER
GE
Gen. Edwards
Br.
POINT OF
PINES
SHUTE BK.
Railroad
Currently Proposed
MBTA Commuter Rail
Station and Parking
SAUGUS
Carey
Circle
STUDY AREA
LIMIT OF TIDAL
FLOODING
Marsh
I-95 Fill
PINES RIVER
Initially Proposed
MBTA Extension
BROAD SOUND
B & M
1A
Revere Beach
Initially Proposed
Revere Connector
1
MALDEN
LINDEN BK.
ATLANTIC
OCEAN
Northgate
99
Elliot
Circle
ROUGHANS
POINT
TOWN LINE BK.
REVERE
1
Broadway
1 - MILE
Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
TRANSPORTATION PLANS
USArmy
Corps Of Engineers
New England Division
June 1989

Figure 1



TYPICAL SECTION
BEACH FILL
EXISTING BOTTOM
SAND FILL
EL 18.0
EL 0.0 (MLW)
LOCATION MAP
SCALE IN MILES
MASS.
Nahant Bay
Broad Sound
REVERE BEACH
Massachusetts Bay
BOSTON
Boston Harbor
Quincy Bay
QUINCY
REVERE
BEACH AREA AT M.S.L.
REVERE BEACH
SAUGUS RIVER
POINT OF PINES
NORTHERN CIRCLE
NORTH LIMIT OF PROJECT
SOUTH LIMIT OF PROJECT
ROUGHANS POINT
ELLIOT CIRCLE
CRESCENT BEACH
WIDEN 13,000 FEET OF BEACH BY DIRECT PLACEMENT OF SAND FILL & PERIODIC NOURISHMENT
BROAD SOUND
PLAN
SCALE IN FEET
BEACH EROSION CONTROL
REVERE BEACH
MASS.
1 JANUARY 1989
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

FIGURE 2



CORPS OF ENGINEERS
U. S. ARMY
BROAD SOUND
SIMPSON'S PIER
STEPPED ACCESS
NEW ARMOR STONE REVETMENT EL. 17.0
REACH "D"
EXISTING CONCRETE WALL EL. 15.3
NEW CONCRETE CAP EL. 17.0
NEW ARMOR STONE REVETMENT EL. 14.0
REACH "C"
STEPPED ACCESS
REACH "B"
REACH "A"
ELIOT CIRCLE
EXISTING MDC PUMPING STATION
NEW 48" GRAVITY DRAIN
NEW 48" SLUICE GATE
NEW INTAKE STRUCTURE
ATLANTIC OCEAN
REACH "E"
EXISTING CONCRETE WALL EL. 17.6
NEW ARMOR STONE REVETMENT EL. 14.0
STEPPED ACCESS
REACH "F"
EXISTING ROAD & EMBANKMENT, EL. 11+
BACKWATER PROTECTION
NEW 42" SLUICE GATE
EARTH BERM EL. 11.0
SAND BAG CLOSURE EL. 18.0
HIGH GROUND
SAND BAG CLOSURE EL. 11.0
HIGH GROUND
R 10/83
NOTES
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
PLAN "A"- STRUCTURAL PLAN
GENERAL PLAN

FIGURE 3

REVERE BEACH RESERVATION • MASTER PLAN

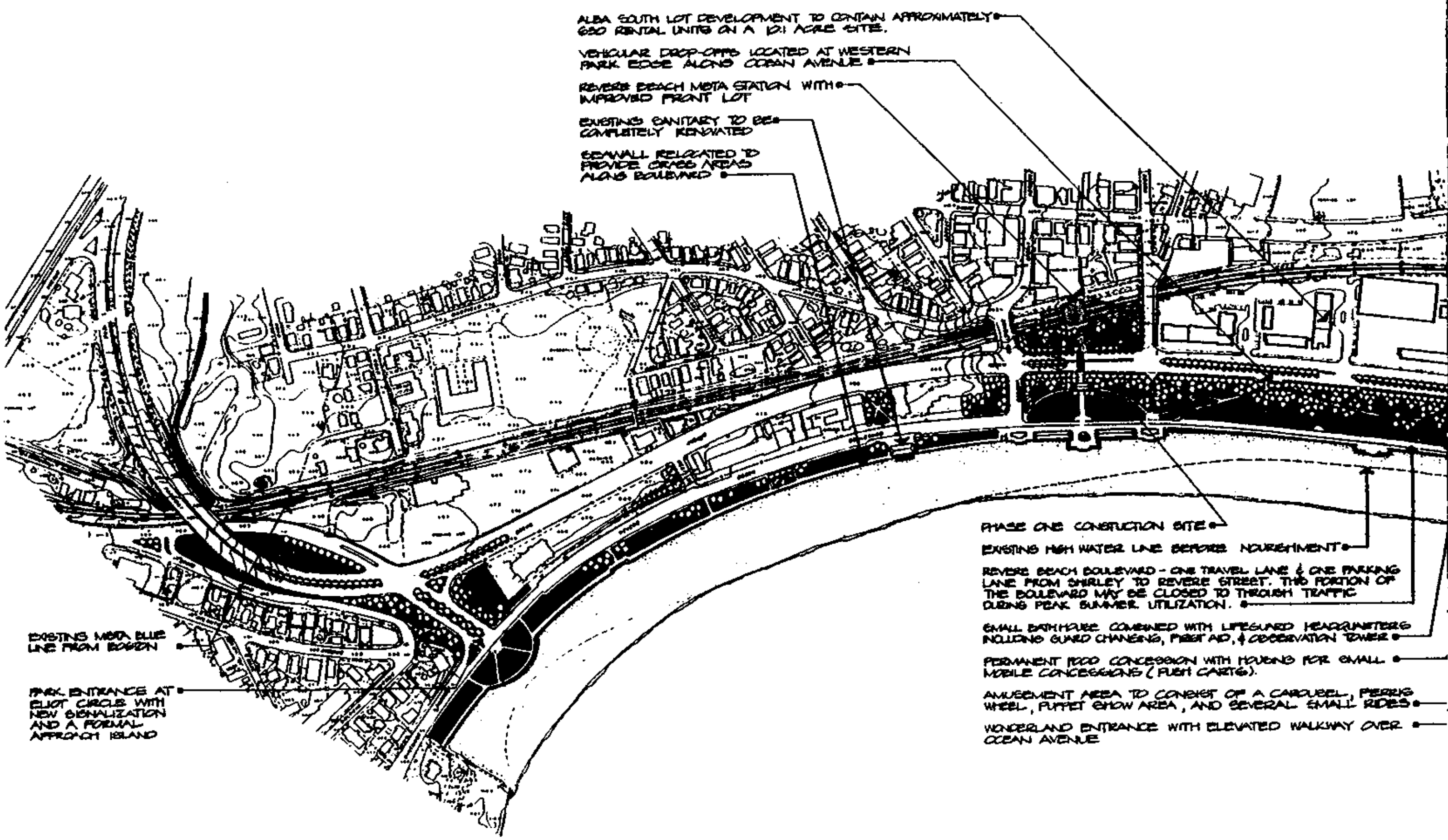


FIGURE 4

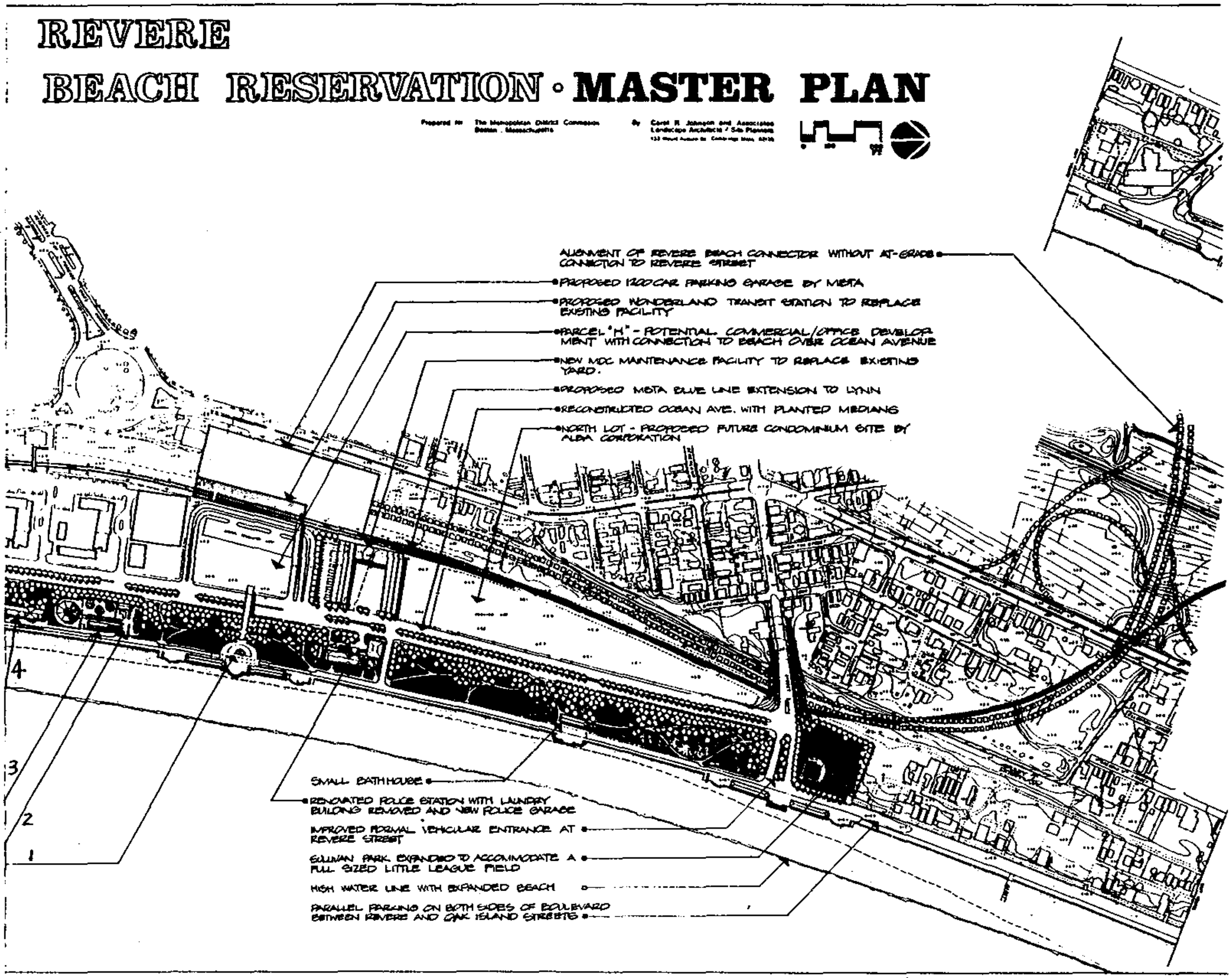


FIGURE 4 Con't

Source: Revere Beach Reservation, Master Plan, Summary Report

e. Storm Drainage and Flooding Roadway and parkland flooding has continually been a problem at Revere Beach during heavy storms. The major flooding occurs at high tide when storm-driven waves overtop the seawall, flow across Revere Beach Boulevard, and down westerly slopes to the lower Ocean Avenue Basin.

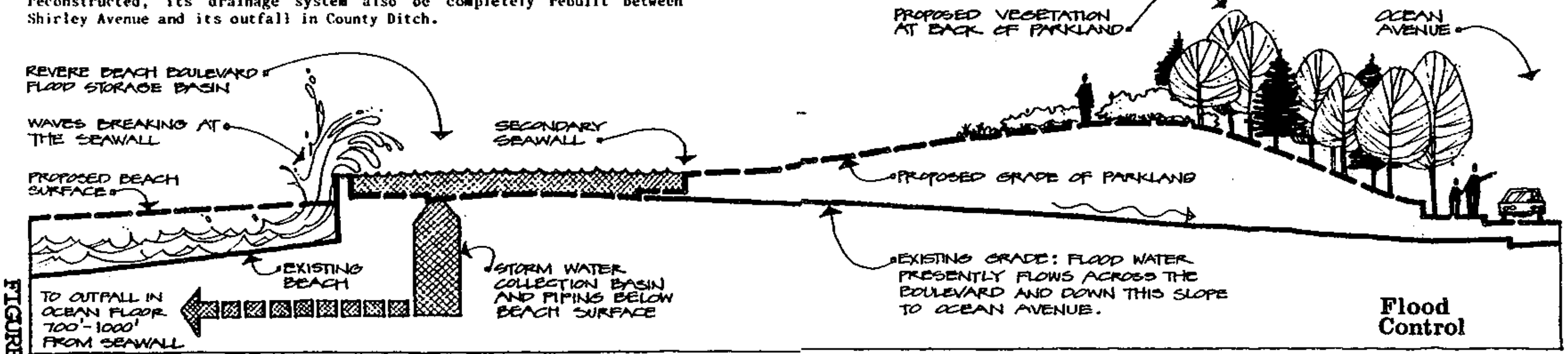
Studies have shown that adequate drainage facilities exist to remove heavy rainfall flood water, however, ocean wave overtopping is a more difficult problem since a very large volume of water is deposited west of the seawall in short of time. Existing drainage facilities are in very poor condition and cannot accommodate this sudden inundation.

The Master Plan recommends several steps to alleviate flooding conditions. Between Beach Street and Revere Street, overtopping flood waters will be contained on the Boulevard and drained eastward under the beach to an outlet in the floor of Broad Sound, 700 - 1000' from the seawall. A key component of this flood control system is the use of the Boulevard as a holding basin bounded by the seawall on the east, a 2' high granite sitting wall or "secondary seawall" on the western Boulevard edge, and high points in the Boulevard roadway preventing flow to the north or south. The parkland will also be mounded to provide increased protection for Ocean Avenue in the event of a hurricane or other severe storm. In addition to its obvious recreational value, resanding of the center section of the beach will serve to reinforce the flood control capability of the new Boulevard. Raising the level of the beach will force waves to break further to the east at high tide rather than at the seawall face, thus reducing the volume of overtopping water.

As major wave overtopping is contained on the Boulevard, the Ocean Avenue drainage system will be required to remove rainfall storm water only. However, due to the age and severely deteriorated condition of Ocean Avenue catch basins and piping, it is recommended that, as Ocean Avenue is reconstructed, its drainage system also be completely rebuilt between Shirley Avenue and its outfall in County Ditch.

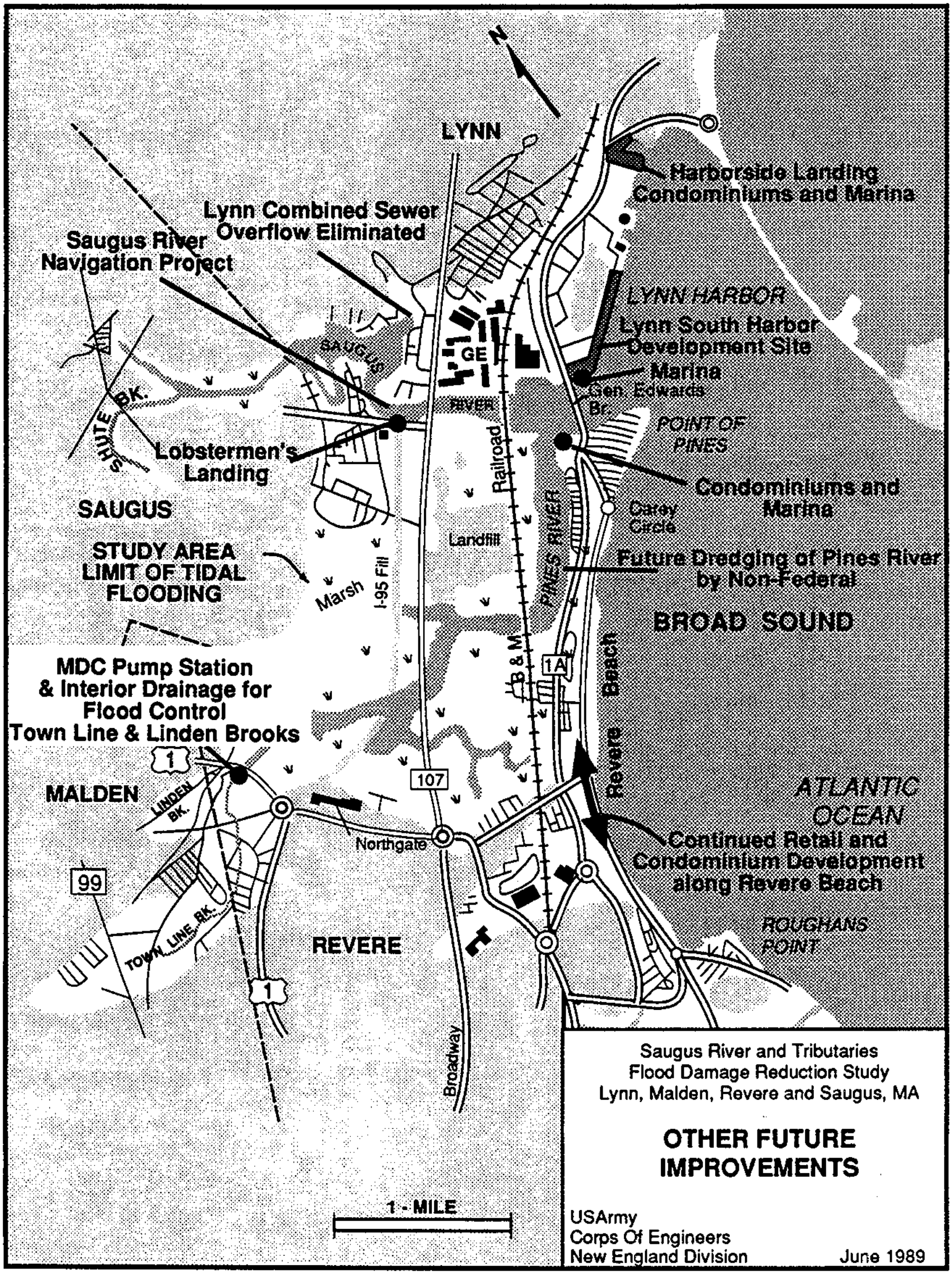
Storm tide at the Bathhouse Pavilions, January 1978.

FIGURE 5



TYPICAL SECTION

Flood control concept. This section looking south shows Revere Beach Boulevard used as a flood storage basin. The Boulevard drainage system carries trapped flood waters eastward below the beach to an offshore outlet in the ocean floor. Constant operation of the system is ensured by the difference in elevation between the water surface on the Boulevard and the ocean surface.



Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA

OTHER FUTURE IMPROVEMENTS

USArmy
Corps Of Engineers
New England Division

June 1989

Figure 6

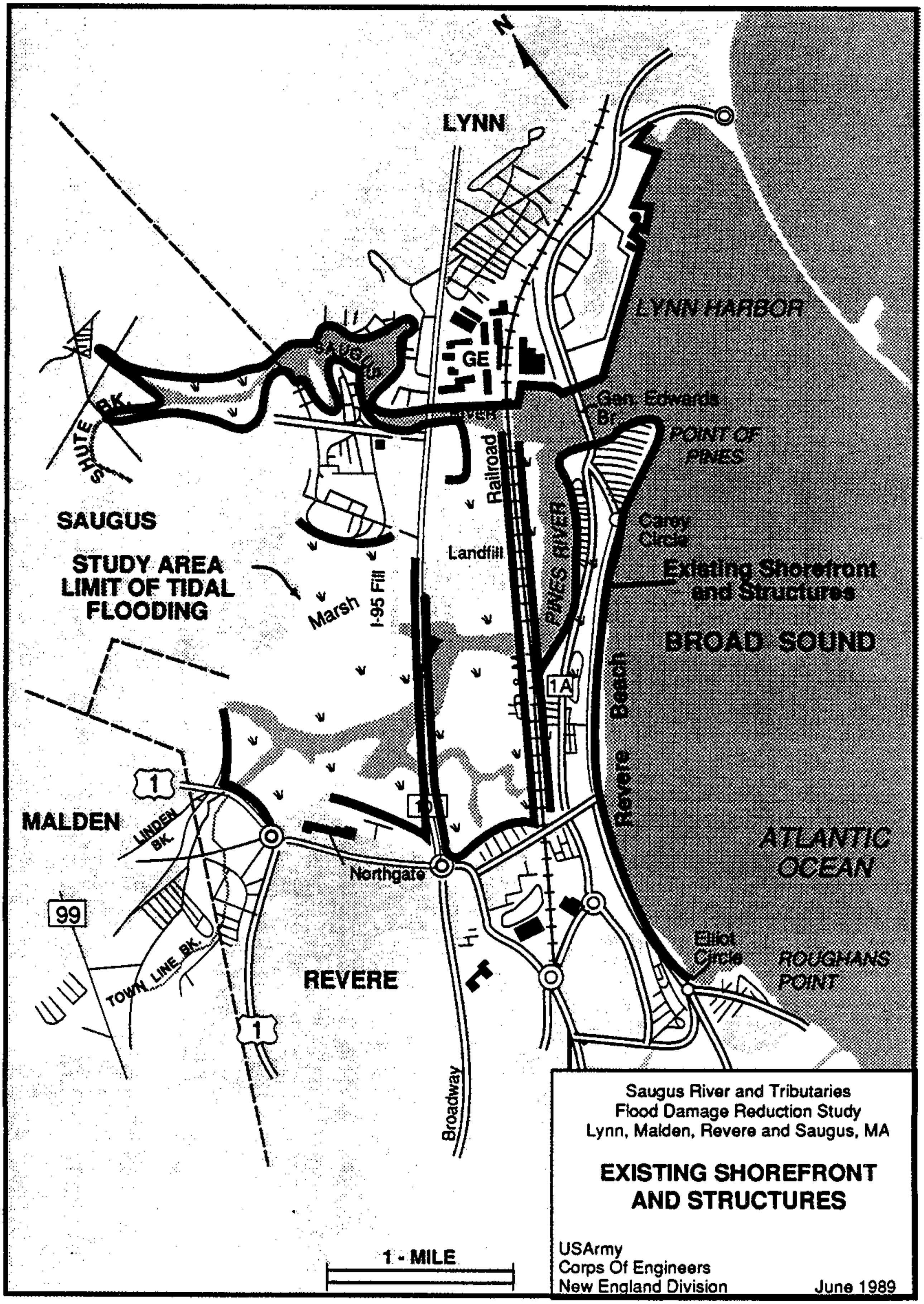
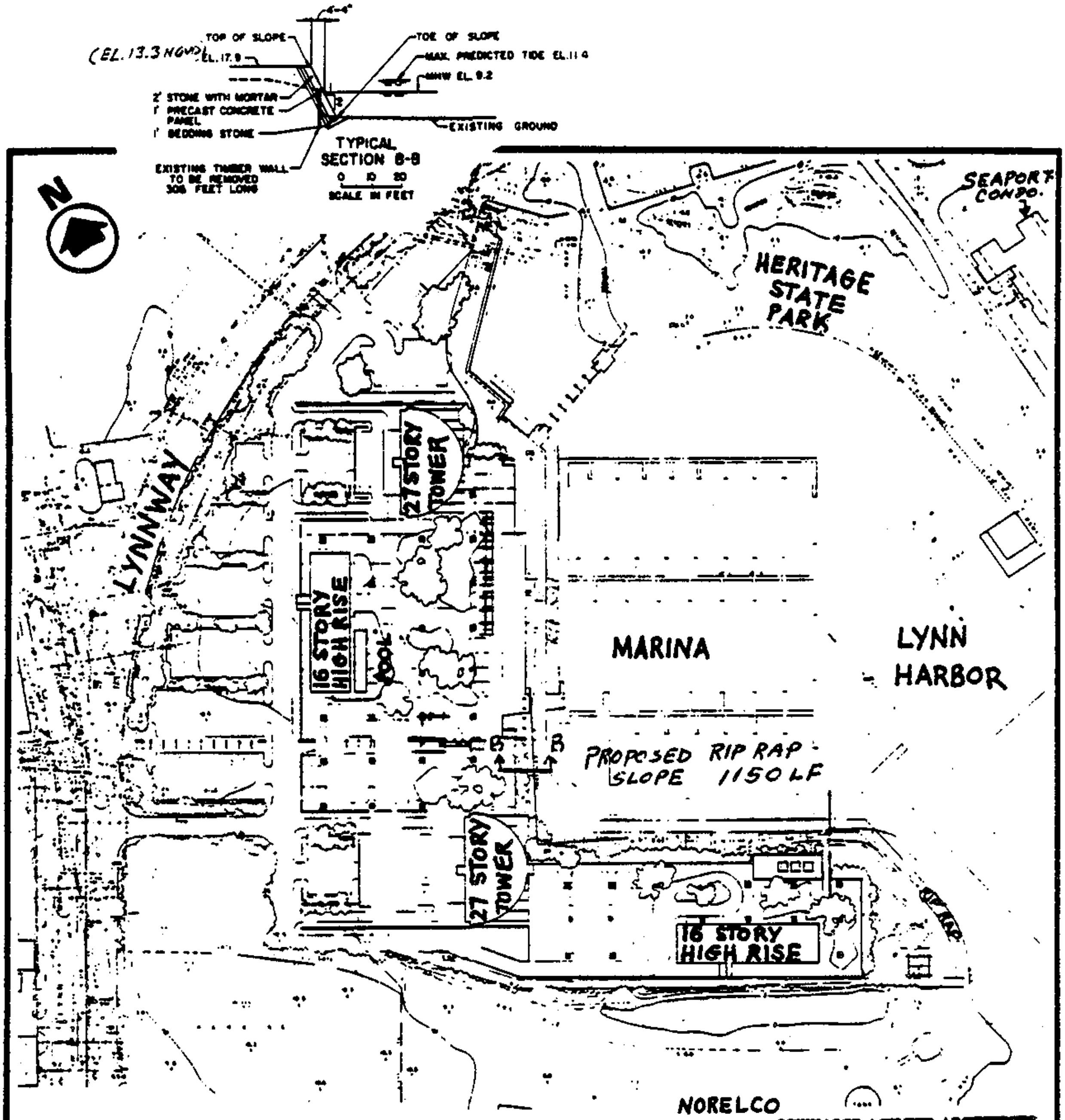

LYNN
LYNN HARBOR
GE
Gen. Edwards Br.
POINT OF PINES
Railroad
Carey Circle
Landfill
PINES RIVER
Existing Shorefront and Structures
BROAD SOUND
SAUGUS
STUDY AREA LIMIT OF TIDAL FLOODING
Marsh
I-95 Fill
SHUTE BK.
1A
Revere Beach
MALDEN
LINDEN BK.
1
Northgate
ATLANTIC OCEAN
99
TOWN LINE BK.
REVERE
Elliot Circle
ROUGHANS POINT
Broadway
Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
EXISTING SHOREFRONT AND STRUCTURES
1 - MILE
USArmy
Corps Of Engineers
New England Division
June 1989

Figure 7

HARBORSIDE LANDING

Proposed Project Plan



Harborside Landing Consists of:

- 452 condo. units (2-27 story towers & 2-16 story high rises)
- Public Marina (88-slip plus ship chandlery, office, laundry & restrooms)
- Parking (678 residential, 182 public)

The total area is 10 acres. Public open space includes 5.9 acres with an oceanfront park, viewing terrace, marina, landscaped areas, and 1,335 feet of public esplanade.

Source: Harborside Landing Draft Environmental Impact Report, May 1986

FIGURE 8

PLAN FORMULATION

The formulation and analysis of alternative plans is based, in part, on review of the existing situation and the problems, needs, and opportunities of the study area.

Alternative measures were investigated to meet the objective of preventing future flood damages from coastal storms. Measure were investigated to determine economic and engineering feasibility, associated environmental and social impacts, and the public attitudes toward it. This appendix describes the alternatives and plans that were studied and the iterative process used to screen them.

MANAGEMENT MEASURES

Measures addressing flood damage prevention fall into two general categories. Some modify the extent of flooding by altering the natural environment, such as breakwaters, seawalls, revetments and other techniques described below. Others reduce flood damage vulnerability through floodplain regulations, flood insurance, floodproofing, relocation and/or acquisition.

Alternative Flood Damage Prevention Measures

Modify Floods	Reduce Vulnerability
Breakwaters	Floodproofing
Seawalls	Flood Warning and Evacuation
Revetments	Flood Plain Regulations
Beach and Dune Restoration	Flood Insurance
Dikes	Public Acquisition of Flood-plain Land
Floodgates	

Modify Extent of Flooding

. Breakwaters. A breakwater is a structure protecting a shore area, harbor, anchorage or basin from waves. Beaches and flood-prone areas along the coast can be protected by an offshore breakwater that can break the wave and reduce the wave energy reaching the shore.

Breakwaters can have both beneficial and detrimental effects on the shore. Offshore breakwaters are usually more costly than onshore structures, such as seawalls or revetments, and are seldom built solely for shore protection. The elimination of wave action reduces the movement of sand along the shore and reduces nourishment of the downdrift beaches.

Breakwaters are generally some variation of an offshore rubble stone mound structure which is adaptable to almost any depth and can be exposed to severe waves. In some instances, both cellular steel and concrete caissons have been used. Breakwaters of these types can be used where storm waves are too severe for rubble stone.

. Seawalls. Protection of shore development can be accomplished when the natural protection is lost to the environment. Shorefront owners can and have resorted to shore protection by constructing wave-resistant walls of various types.

Seawalls may have vertical, curved or stepped faces and can be constructed of many different types of materials. While seawalls may protect development, they can also create a local problem. The downward forces created by waves striking the wall can rapidly remove sand from in front of it. A stone apron is often necessary to prevent this excessive scouring and undermining.

. Revetments. Sloping revetments armor the seaward face of a shoreline with one or more layers of stone or concrete. This sloping protection dissipates wave energy, with a less damaging effect on the shore. Two types of structural revetments are used for coastal protection: the rigid, cast-in-place concrete type and the stone armor unit type.

. Beach Restoration and Nourishment. Beaches are very effective in dissipating wave energy. When maintained to adequate dimensions, they can afford protection for the adjoining backshore. When conditions are suitable, long reaches of shore may be protected by artificial nourishment at a relatively low cost. The resultant widened beach also has added value as a recreational feature.

. Dikes. With this measure, small earth embankments can be built around vulnerable structures or groups of structures to prevent floodwaters from reaching developed areas. Depending on wave action or currents along a riverbank, the dike may have a protective stone facing. Although dikes are usually less costly than other measures, they are wide structures and require more real estate for their construction than a wall.

. Sand Dune Development. Sand Dunes can provide a natural barrier to flood tides. Dunes however to remain effective must have a natural supply of sand and gradual sloping beach fronting the dunes. The stability of a dune against very severe storms can be estimated based on new technology. Dunes can be breached in a single storm is not properly designed. Sand Dunes can assume to be effective for recurring storms of similar magnitude to those storms previously experienced if breaching did not occur. During major floods, the dune line is sometimes breached or flanked, and flooding takes place behind the dunes. Sand fences in various areas along the shoreline can be very effective in trapping sand to build up low points, strengthen narrow sand ridges, and generally build up any existing dunes. Once the sand dunes are built up to the desired height, they should be stabilized and protected by vegetation.

Use of American beach grass to stabilize and enhance protective dunes has been successful at several sites on the Atlantic coast.

With proper fertilizing techniques, the grass can be induced to produce an extensive root system from which additional plants will rise to the surface. Continued protection can only be afforded if recommended fertilization and cultivation procedures are observed. Controlled access is essential for maintenance of dunes. This can be accomplished with wooden walkways or with rolled clay pathways over the dunes. Although the growth is dense, it is sometimes necessary to erect fences to prevent random access to the beach and needless erosion. Sand dunes create a natural system which also helps protect and prevent erosion of the beach, provide habitat for wildlife, and provide an aesthetic border for any shorefront.

. Floodgates or Tide gates. Floodgates can be used to close off rivers, streams, drainage ditches or pipes to prevent tide waters from flowing up or into these natural or man made waterways.

Tide gates usually refer to gates used on culverts which drain water under roadways or from neighborhood catch basins.

Floodgates in this study are being considered to prevent tidal surges up the Saugus and Pines Rivers. Floodgates have been built around the world to prevent tidal surges from entering estuaries, bays, harbors or rivers and flooding developed properties. They are generally designed to maintain the natural tidal flushing of an area and are only closed for a threat of flooding.

Well known floodgates have been built on the Thames River in England, and for the Delta Project in the Netherlands. Another is planned to protect Venice.

In the United States most floodgate structures of any size have been built in New England by the New England Division, Corps of Engineers. They include projects designed against high tide levels; including the :

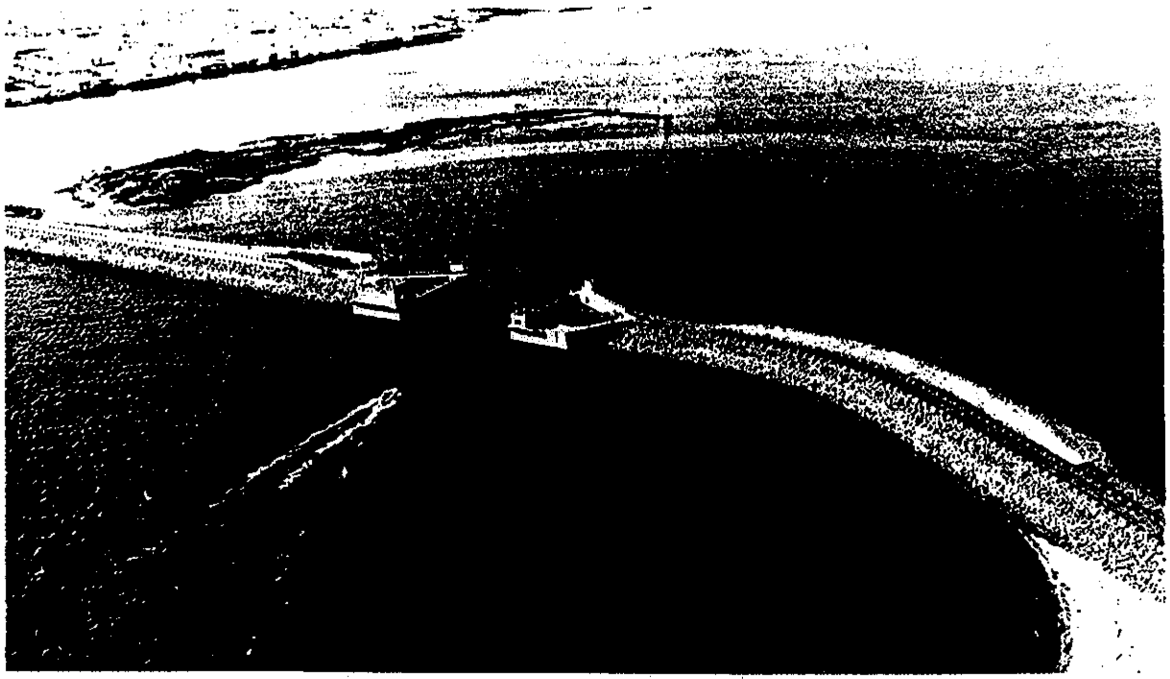
1. Fox Point Hurricane Flood Protection Project, Providence, Rhode Island, visited by the Technical and Citizen Committees (Plate Q-6).

2. New Bedford Hurricane Flood Protection Project, New Bedford, Fairhaven and Acushnet, Massachusetts, also visited by the Committees.

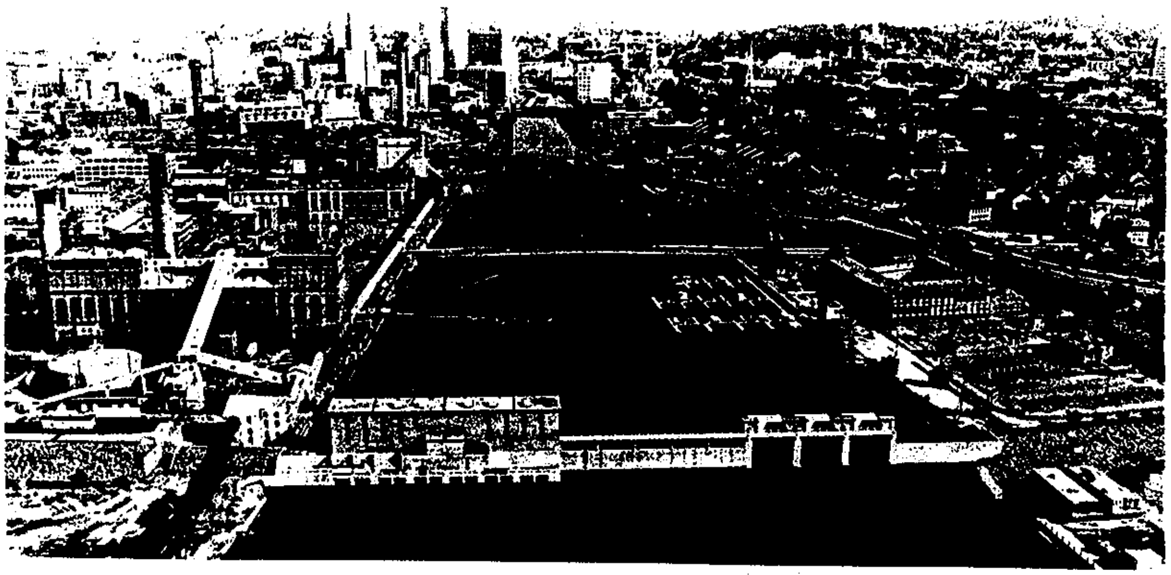
3. Stamford Hurricane Flood Protection Project, Stamford, Connecticut (Plate Q-7).

4. Charles River Dam Project, Boston and Charlestown, Massachusetts.

Two other hurricane barrier projects without floodgates are: (1) Pawcatuck Flood Protection Project, Stonington, Connecticut, (2) New London Hurricane Flood Protection Project, New London, Connecticut.

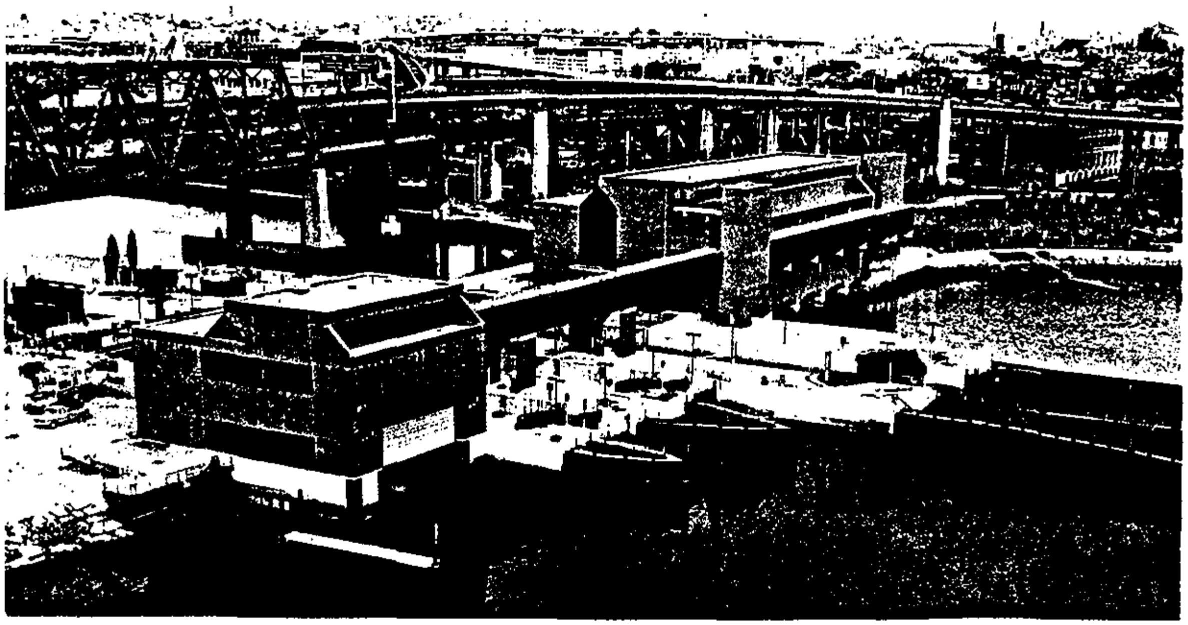


NEW BEDFORD, FAIRHAVEN, AND ACUSHNET HURRICANE FLOOD PROTECTION - This project provides tidal flood protection for the New Bedford area. This project was completed by the Corps of Engineers in 1966. The project includes a barrier across New Bedford - Fairhaven Harbor, and consists of 8,000 feet of earthfill dike. A gated opening, 150 feet wide, accommodates barge traffic and recreational navigation. The Corps of Engineers operates and maintains the navigation gate and main harbor barrier with funds provided by local interests through prepayment to the Federal Government.



FOX POINT HURRICANE FLOOD PROTECTION PROJECT - Completed by the Corps of Engineers in 1966 at a cost of $14.8 million, located 1 mile south of the heart of Providence, R.I., along the tidal estuary of the Providence River. The barrier consists of a concrete gravity dam about 700 feet long with connecting dikes. Included in the barrier are three river gates and a pumping station. The river gates, with three 40-foot openings, pass normal river and tidal flows while permitting passage of small boats and barges. When closed, the project prevents the entry of tidal floodwaters from the bay. Maintenance and operation of the project became the local responsibility in August 1966.

STAMFORD HURRICANE FLOOD PROTECTION PROJECT - Completed in 1969 by the Corps of Engineers, at a cost of $13.5 million, the project extends across Stamford Harbor. It includes 11,700 feet of protective works, principally dikes, and includes a 90-foot gated navigation opening. The flap-type gate normally rests on the harbor floor, and can be raised on steel arms in 20 minutes to seal the harbor against tidal surges. Local interests operate and maintain the project with the exception of the navigation gate. Local interests made a cash payment toward the first cost of the project in lieu of operating and maintaining the gate, which is accomplished by the Corps.



CHARLES RIVER DAM PROJECT - Completed by the Corps of Engineers in 1978 at a cost of $59 million, located between Charlestown and Boston's North End. The project includes a fishway, a pumping station and three navigation locks across 440 feet of the Charles River and 350 feet of earthfill dam across the rest of the river. To harmonize the project with the historic environment of the communities it protects, the structural design features a facade of red water-struct brick traditional to Boston. The new Paul Revere Landing Park on the Charlestown abutment commemorates the Patriots midnight ride. The preservation of 8500 acres of wetlands as part of the Natural Valley Storage component of the project received several environmental awards. The Metropolitan District Commission operates and maintains the dam.

There are a number of different types of floodgates. Sector Gates can be used to close out high hurricane forced tides such as New Bedford's 150 foot wide navigation gate, or for boat passage through the locks at the Charles River Dam in Boston. The gates are sectors of a circle and roll out from each side of the gate structure to close off the channel. A Flap-type Gate at Stamford normally rests on the harbor floor, then is lifted up to close off the harbor. A Miter Gate is used for large locks in the mid-West where wave action is limited to only a few feet, such as the entrance to the Saugus River. Miter gates are two large steel hinged doors which close at a bevel or miter.

The Tainter Gates at Fox Point are normally in a raised position and are lowered to close off the opening.

There are gates that lift, slide and float to the surface, all designed depending on particular conditions or purpose.

REDUCE VULNERABILITY

. Ponding Areas. Natural or man-made ponding areas can be preserved or constructed to store flood waters to reduce or prevent damages to buildings.

. Floodproofing. This encompasses a body of techniques for preventing damages due to floods, requiring action both to structures and to building contents. It involves keeping water out, as well as reducing the effects of its entry. Such adjustments can be applied by the individual, or as part of a collective action, either when buildings are under construction or during temporary remodeling. They may be permanent or temporary.

Floodproofing, like other methods of preventing flood damages, has its limitations. It can generate a false sense of security and discourage the development of needed flood control and other actions. Indiscriminately used, it can tend to increase the uneconomical use of flood plains resulting from unregulated flood plain development. Each measure must be evaluated for its specific application in the reduction of flood damages, and only then can it be decided if that particular measure is feasible -- physically and economically.

Floodproofing measures can be classified into three broad categories. First are permanent measures which become an integral part of the structure or land surrounding it. Second are temporary or standby measures which are used only during floods, but which are constructed and made ready prior to any flood threat. Third are emergency measures which are carried out during flood situations in accordance with a predetermined plan. In recent years, floodproofing has come to be known as "nonstructural" to be distinguished from "structural" which is traditionally associated with major flood control works.

Nonstructural flood damage reduction measures have an important role alongside traditional structural measures. Continued occupancy of developed flood plain sites, and even new development of such sites, may be necessary in some low-lying places - especially in certain urban areas where a shortage of land may offer no other realistic alternative. Typical nonstructural measures include closures for openings (doors, windows, etc.), waterproof sealants for walls and floors, utility valves to prevent backflow of sewer and plumbing facilities, and sump pumps. Another technique is raising existing structures above flood levels.

Within an existing group of structures, damageable property can often be placed in a less vulnerable location or protected in-place. It is something every property owner can do to one degree or another. Furnaces and appliances can be protected by raising them off the floor. Damageable property can be moved from lower to higher floors, or other less flood-prone sites. Important mechanical and/or electrical equipment can be flood-proofed by enclosing them in a watertight utility cell or room.

A consideration that must be included is that residual damage to both the structure and contents will remain even when the most vulnerable property is rearranged or protected. Measures such as these are usually considered when other measures are either not physically or economically feasible, or the depth of flooding is relatively shallow.

Elimination of flood damages can also be accomplished by relocation of existing structures and/or contents. There are basically two options for removing property to a location outside the flood hazard area. One is to remove both structure and contents to a flood-free site; the second is to remove only the contents to a structure located outside the flood hazard area, and demolish or reuse the structure at the existing site. In each case, the purpose is to take advantage of the existing property in a manner compatible with the flood hazard.

. <u>Flood Warning and Evacuation</u>. Flood forecasts, warning and evacuation is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.
- Procedures for issuance and dissemination of a flood warning.
- Arrangements for temporary evacuation of people and property.
- Provisions for installation of temporary protective measures.
- A means to maintain vital services.
- A plan for postflood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process will communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday) and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain the credibility of future warnings.

An effective warning needs to be followed by an effective response. This means prompt and orderly evacuation and/or action. This includes:

- Establishment of rescue, medical and fire squads.
- Identification of rescue and emergency equipment.
- Identification of priorities for evacuation.
- Surveillance of evacuation to insure safety and protect property.

. Flood Plain Regulations. Through proper land use regulations, flood plains can be managed to insure that their use is compatible with the severity of a flood hazard. Several means of regulation include: zoning ordinances, subdivision regulations and building and housing codes. Their purpose is to reduce flood losses by controlling the future and existing uses of flood plain lands.

Zoning regulates the use of structures and land, the height and bulk of buildings, and the size of lots and density of use. It is usually based upon some broad land use plans to guide the growth of the community. Subdivision regulations guide the division of large parcels of land into smaller lots for development. Subdivision regulations with special reference to flood hazards often (1) require installation of adequate drainage facilities, (2) require filling of a portion of each lot to provide a safe building site at an elevation above the selected flood height, and (3) require the placement of streets and public utilities above a selected flood protection elevation. Building and Housing Codes neither regulate where development takes place nor the type of development, but rather specify building design and materials.

. Flood Insurance. Flood insurance is not really a flood damage reduction measure; rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners. Prior to this program the response to flood disaster was limited to the building of flood control works and providing disaster relief to flood victims. Insurance companies would not sell flood coverage to property owners, and new construction would often overlook new flood protection techniques.

The National Flood Insurance Program is conducted by the Federal Insurance Administration (FIA) under the direction of the Federal Emergency Management Agency (FEMA) -- formerly the Department of Housing and Urban Development, Flood Insurance Administration. The program provides local officials with a usable tool for protection of their flood plains. A flood-prone community, once on the regular program, must enact floodplain zoning in accordance with minimum guidelines established by FEMA. Failure to enact or enforce such legislation could be penalized by forfeiture of all Federal funding assistance.

Flood insurance is an option for all owners of existing buildings in a community identified as flood-prone. It is compulsory for all new buyers of property in the FEMA designated 100-year flood plain where Federally insured mortgages or mortgages through Federally connected banks are involved.

In order to qualify, a community must adopt preliminary flood plain management measures including floodproofing for all proposed construction or other development. They must be reviewed to assure that sites are reasonably free from flooding; all structures in flood-prone areas must be properly anchored and made of materials that will minimize flood damage; new subdivisions must have adequate drainage; and new or replacement utility systems must be located to prevent flood loss.

. Public Acquisition of Flood Plain Land. Public control over the flood plain may be obtained by purchasing the title or some lesser rights such as development or public access rights. Acquisition of the title is better suited for undeveloped or sparsely developed land in the flood plain. It is a very desirable means for providing environmental and wildlife protection, public open space, recreation and other purposes.

PLANS OF OTHERS

A variety of Commonwealth of Massachusetts activities and programs have direct bearing on water and related land uses in the study area. Those relevant to this study are described here.

. The Department of Environmental Quality Engineering (DEQE) has plans to construct improvements along Sales Creek, southwest of Roughans Point. These improvements were initiated in 1980 for the purpose of alleviating the creek's periodic flood problems and are near completion. Measures include a pumping station at Bennington Street where Sales Creek empties into Belle Isle Inlet, replacement and enlargement of most of the existing culverts, excavation of sediment and removal of debris from the channel and enclosure of two reaches in pipe conduits.

. The Coastal Zone Management Program (CZM) offers technical assistance to communities, provides for federal consistency with policies, and above all, sets a high priority on placing the state's regulatory and management programs in order thus making them work in a more assured, timely and consistent manner. The Massachusetts CZM program protects the coastline's natural resources and insures that the environmental and economic values of the coastal zone be maintained, and even enhanced.

. The Statewide Comprehensive Outdoor Recreation Plan (SCORP) prepared by the Department of Environment Management (DEM), recommends that recreational needs be met where demand is greatest and supply most deficient, and that priority be placed on satisfying the needs for the most widely demanded recreational activity. The plan identifies swimming as the most popular recreational activity and finds that urban areas, particularly the greater Boston area, have the highest need for new recreational facilities.

. The State Growth Policy Plan, prepared by the Office of State Planning (OSP), recommends that new growth and development be channeled to existing urban centers or to regional development centers, and that State programs of public investments adhere to the policy and support urban development.

. Plans have been prepared by the city of Revere, the MDC, and private concerns for redevelopment of Revere Beach. These include the construction of two residential complexes, one to be luxury apartments and an elderly housing project, and the other to be condominiums. The MDC has planned a park on its Revere Beach Reservation. The MBTA is planning to extend its Blue Line public transportation system, rebuild the Wonderland Station, and construct a parking garage. Rehabilitation of the beach area has been initiated. However, completion of the comprehensive plan is contingent on the availability of funding.

PLAN FORMULATION RATIONALE

During the course of the study, preliminary plans were evaluated for feasibility in satisfying the national and study objectives, flood protection needs, economic justification, environmental and social acceptance and impenetrability. These plans were formulated to decide if further studies should continue and which plans warrant detailed study.

The elevation datum used throughout the report is feet above the National Geodetic Vertical Datum (ft. NGVD). Zero NGVD datum is about 4.5 feet above mean low water.

The frequency and depth of potential future flooding was developed from several sources including an analysis of known historical levels, including field interviews. For example, the record event of 6 & 7 February 1978 produced water levels generally ranging from 9 to 14 feet NGVD. Similarly, based on available information and interviews, the February 1972, November 1968, January 1979 and January 1987 events produced interior water levels of approximately 9.0 feet NGVD. The frequency of these events and the statements of residents reporting ponding depths in their home, business or on the streets was the basis for adopting the projected frequency and depth of future flooding. Historical flood levels and statistical analysis of Boston tide levels calibrated with modeling and gaging stations in Broad Sound and on the Saugus and Pines Rivers were used to project future interior flood stages in the study area.

Where damages from large floods would be catastrophic the SPN is the goal for the level of protection. The SPN flood is that flood which might be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the region involved, excluding extraordinarily rare combinations. This policy is particularly applicable to projects involving urban areas. As explained in the Main Report, the SPN tide level estimated for Broad Sound is elevation 12 feet, NGVD.

The February 1978 storm's stillwater tide level of 10.3 feet NGVD, is the greatest observed tide in Boston and has a 1.0 percent chance of occurrence each year (100-year recurrence interval).

The following explains why the 100,500 and SPN levels were selected for formulating and evaluating plans. The 1978 storm has a frequency of occurrence of 1 percent chance each year or about a 100 year storm. With the historical rate of sea level rise this frequency is expected to change each year during the life of the project. In other words, the severe damages accompanying the 1978 flood of record would eventually become about a ten year event with a one foot rise in sea level. If accelerated sea level rise should materialize, the 1978 storm would become more frequent. Flood protection in the study's urban area, threatened by rising sea levels and prone to historical and catastrophic damages, should be designed for the highest level of protection possible or the SPN. However, in the event the SPN level of protection is not justified economically or environmentally or is not acceptable socially then lower levels should be considered. Tidal flooding in the area occurs as a result of many factors; tide levels, wave action, winds and their direction and the height of shorefront structures and interior runoff, to list a few. For protection against tidal flooding, the frequency of stillwater tide levels reasonably represents tide related factors during storm conditions and thus provides a basis to formulate plans against tidal flooding. The stillwater tide level and its historical frequency assigned is useful in analyzing tidal overtopping and establishing the heights of structures needed for a particular level of protection, as well as assigning benefits or damages prevented to that same frequency.

There are about one foot differences in the stillwater tide levels between the following events: the 10 year event at EL. 9.2, 100 year at EL. 10.3, 500 year at EL. 11.2 and SPN at EL. 12.0 stillwater tide levels. This small incremental change in height of about one foot between each event produces significantly higher differences in frequencies of protection.

Due to the fact that over the project life the existing ten year event would become a one year event with historical sea level rise, it is inappropriate to formulate a plan that over its 100 year life would change from providing ten year protection to only one year or less. Thus, a 10 year level of protection is not being considered further in this investigation.

In order to economically optimize a plan three plans are normally used to determine when the highest net economic benefits are achieved. Since there's less than one foot difference between the 100 year, 500 year and SPN levels - they are selected for optimizing plans.

SCREENING PLANS

The 500 year level is an intermediate point among the three levels of protection and was selected for screening structural plans. Normally, the SPN is not economically justified, due to its low recurrence frequency and resulting low incremental additional benefits needed to incrementally justify additional costs to reach SPN protection. Both the Roughans Point and Point of Pines local protection projects were incrementally optimized at about a level of protection where significant damages were prevented at the 100 year event.

However, during the initial investigation of the Revere Beach Backshore area preliminary planning found that the 500 year design storm condition produced the highest net benefits. Thus, when the regional study for the Saugus River and Tributaries started, all structural plans were screened at this level of protection. Nonstructural plans as found in other studies usually produce their highest net benefits at the 100 year level since their analysis is on a building by building basis. Once the preferred plan is selected it is optimized for net benefits usually by preparing three plans providing either the 100 year, 500 year or SPN design protection.

In order for a plan to incrementally and economical justify a high level of protection, there must be a low increase in project costs accompanied by a higher incremental increase in benefits. The preliminary Revere Beach Beachshore local protection plan (LPP) was initially optimized at a higher level (500 year) than either Roughans Point or Point of Pines due to this reason. A large number of buildings could be protected at a higher level with less incremental increase in the cost of the protection. Conversely, for non structural measures, the increased cost of raising or flood proofing each building protects only the one building, thus one reason a 100 year level is usually selected. One factor which affects the incremental increase in benefits at the 100 year is that the majority of flood insurance benefits (or reduction in insurance costs) are achieved by raising the first floor above the 100 years level.

Therefore, the 500 year plan (SWL at EL.11.2) was selected for screening structural plans and 100 year (SWL at El.10.3) for nonstructural in an attempt to give each a good chance of achieving their highest net benefits. Again there is only about a one foot difference in the heights of flooding and protection in both cases or between levels of protection.

This approach of screening plans at the 500 or 100 year level would considerably save resources, both time and study costs, rather than optimize every plan investigated. The end results however should be evaluated to assure the optimum plan has been identified.

PLAN FORMULATION CRITERIA

The following guidelines and criteria were used in the formulation of preliminary plans:

CORPS CRITERIA AND GUIDELINES

The Corps of Engineers Principles and Guidelines, were followed in the conduct of this study. Other applicable Federal laws and guidelines were also used as explained throughout the report. Alternative plans which contribute to the Federal objective should be systematically formulated. In addition to a plan which reasonably maximizes net economic benefits, or maximizes contributions to National Economic Development (NED), other plans may be formulated which reduce net NED benefits in order to further address other federal, state, local and international concerns not fully addressed by the NED plan. These additional plans should be formulated in order to allow the decision maker the opportunity to judge whether these beneficial effects outweigh the corresponding NED losses or project costs.

In general, in the formulation of alternative plans, an effort is made to include only increments that provide net NED benefits after accounting for appropriate mitigation costs. Appropriate mitigation of adverse environmental effects, as required by law is included, in all alternative plans. Increments that do not provide net NED benefits may be included, except in the NED plan, if they are cost-effective measures for addressing specific concerns.

Alternative plans, including the NED plan, should be formulated in consideration of four criteria: Completeness; effectiveness; efficiency; and acceptability.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective. Each plan must be complete within itself to provide the benefits claimed for that plan.

Effectiveness is the extent to which the alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

The NED Plan - A plan that reasonably maximizes net national economic development benefits, consistent with the Federal objective, is to be formulated. This plan is to be identified as the national economic development plan.

Other Alternative Plans -

(a) Other alternative plans should be formulated to adequately explore opportunities to address other federal, state, local and international concerns not fully addressed by the NED plan.

(b) The number and variety of alternative plans should be governed by-

(1) The problems and opportunities with the water and related land resources in the study area;

(2) The overall resource capabilities of the study area;

(3) The available alternative measures; and

(4) Preferences of and conflicts among state and local entities and different segments of the public.

(c) When institutional barriers would prevent implementation of an economically attractive plan, alternative plans which include removal of those barriers should be presented where such plans are implementable.

MEPA GUIDELINES

The Massachusetts Environmental Policy Act (MEPA) process also requires the evaluation of alternatives and display of impacts.

Even though lack of support was very evident for some options investigated, all options received several levels of formulation to make them more complete and potentially more acceptable. This was accomplished in the event the preferred option should unexpectedly result in problems precluding its implementation. The reformulation of those options provide a reasonable assessment of their feasibility, impacts and implementability

EXISTING SHOREFRONT STRUCTURES - CRITERIA/EVALUATION

There are over 30 miles of existing shorefront and structures in the study area. The following methods were used to describe the shorefront structures and determine if improvements were needed to reduce flooding. The shorefront was divided into different reaches. Each reach has generally a single type of structure, at the same height. This was necessary to determine whether flooding was or was not caused as a result of overtopping each reach and, the extent of the overtopping. Also evaluated was whether the shorefront would need total replacement, modification of the existing structure, or no change at all, to reduce flooding in the area behind it. Alternative improvements were evaluated by reach.

In evaluating the different reaches along the shorefront to determine what needed to be done, the following criteria and methods were used for the selected level of protection:

. The shorefront structure would first be evaluated during field inspections by a multi disciplined study team including persons trained in structural and foundation analysis and design, economics, real estate, biology and a representative of the community. The investigation would collect information on the existing and historical condition of the structure and formulate alternative improvements.

. Owners of the structures and nearby property owners were interviewed to determine the history of the structure. This interview included it's structural age, how it was replaced, and whether it was overtopped or damaged in 1978 or any other flood event.

. The shorefront was later analyzed for its existing condition to determine the top of wave run-up on the structure and type of waves hitting it. Survey data was also obtained to determine the structure's profile, for example, the elevation for the top of the structure and ground elevation on each side of it, and the slope of the ground fronting it.

. If a structure would be significantly overtopped or could fail during a selected design flood event, improvements would be needed.

. The structure could be assumed stable if "as built" drawings of its construction (when analyzed) proved it was properly designed, and if field inspections proved no significant defects or historical failures.

. If there was no failure or repairs required in 1978 and the exposed structure appears stable, but there were no "as builts" to show its foundation design, then the structure would normally require only measures to stabilize its foundation.

. Damaged or deteriorated structures would likely need to be totally replaced.

. If any structure were determined to be stable during planning with no improvements required, then it would be subject to additional investigation during design of a project. The continued maintenance of the structure would also be required for any project.

In summary, the results of investigating each reach determined whether it was overtopped, currently stable, could be raised, would need foundation improvements, would be totally replaced, type of structure to replace it, and the social, environmental, technical and economic considerations for improving each reach.

NONSTRUCTURAL CRITERIA

The criteria used to develop nonstructural flood proofing plans for the 100 year level of protection included:

. residential areas were investigated for raising buildings, limited to one and two story family residences, where 100 year flood levels reached the first floor.

. commercial and industrial buildings and multifamily or condominium buildings would be investigated for flood proofing using shields at windows and doors. Also ring walls around storage areas would be considered.

. for flood levels above the concrete foundation or first floors, only those buildings constructed of concrete or brick would be considered for shields. Wooden structures would not be floodproofed with shields.

. residential buildings would be evaluated for protection of their utilities with a water tight utility cell within the existing home or construction of a water tight "utility room" addition to the home.

. all flood proofing measures include water tight foundations.

SCREENING OF PLANS

One measure for flood damage reduction was screened out for feasibility in satisfying the needs of the Study Area. Below is a brief synopsis of the results of the evaluation.

Floating breakwaters, anchored offshore to intercept incoming waves were determined not to be implementable. Such a breakwater should not be subjected to a design wave with a period of 4 seconds or more, or a wave height greater than 4 feet (Technical Report HL-80 Floating Breakwater). The design wave height for Revere Beach is about 9.0 feet; and in Lynn Harbor reaches 3.4 feet with a maximum wave period of about 4.5 seconds. Therefore, this design is not applicable to the Revere Beach or Lynn Harbor areas.

PLANS (OR OPTIONS) OF PROTECTION

Three basic plans or options were prepared using management measures. These options include various combinations of management measures, as follows:

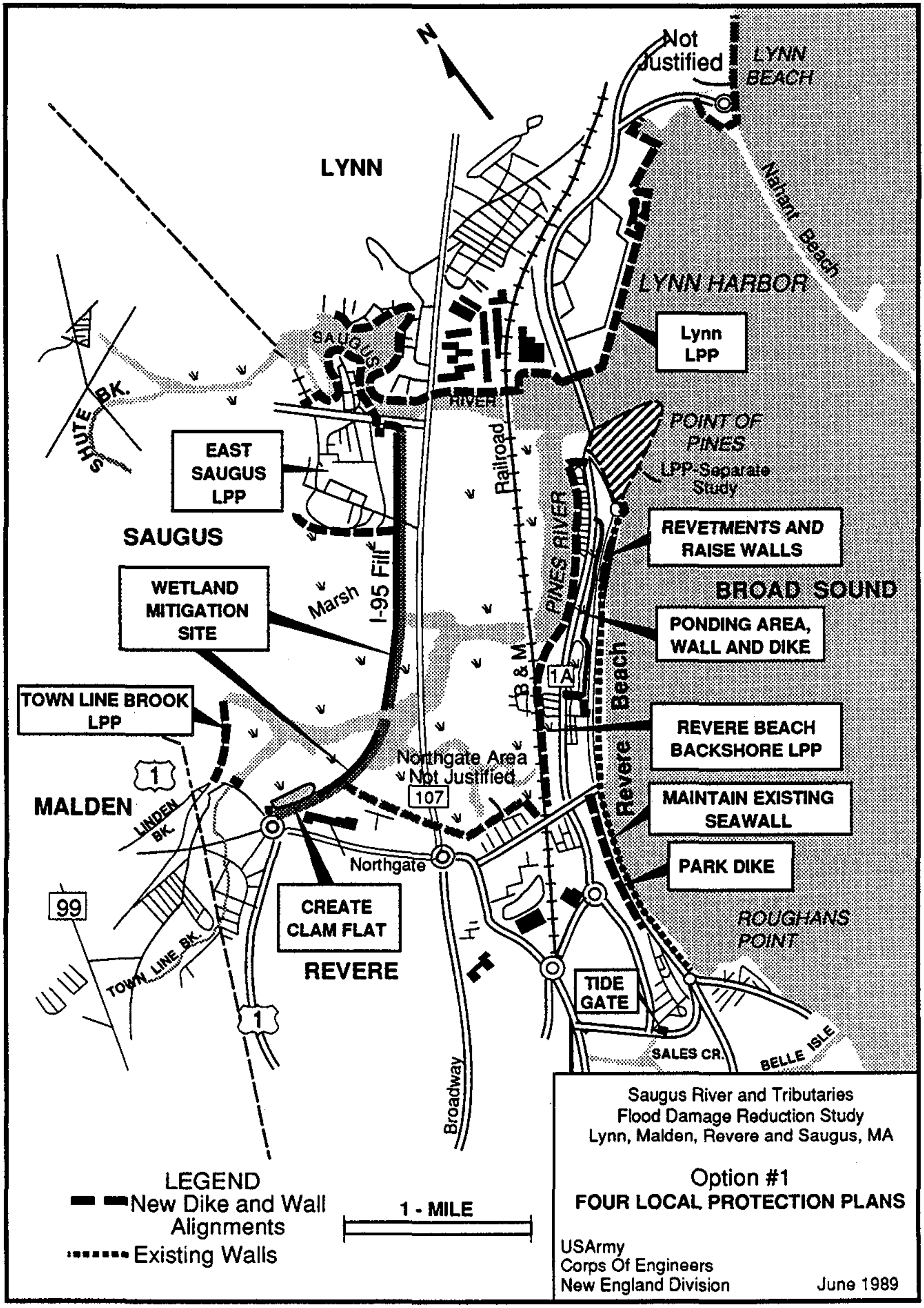
(1) Option 1 - Local Protection Plans would separately protect individual geographic areas with experienced concentrated damages. Measures would include for example, walls, dikes or revetments along the shorefront to high ground to reduce overtopping, ponding areas for flood storage and flood warning and evacuation measures and pumping stations, if needed, and existing regulatory controls, such as wetland regulations, flood plain management, flood plain zoning and flood insurance.

(2) Option 2 - Nonstructural Plans would include regulatory controls flood warning and evacuation measures and flood proofing for individual or small groups of structures. Floodproofing would include home raising, utility rooms or cells, flood shields, (blocking doors or windows) and walls around groups of buildings or commercial storage areas.

(3) Option 3 - Regional Floodgate Plan would include floodgates across the Saugus or Pines Rivers tied into shorefront protection to high ground, ponding areas (e.g., the estuary) and flood warning and evacuation measures, regulatory controls, and pumping stations, if needed.

OPTION #1 LOCAL PROTECTION PLANS

The study area was divided into eight geographic areas, each with varying degrees of development. The more development and potential damages in the area, the more likely the area could be protected by a wall or dike system along the shorefront, justified to prevent damages. Five areas appeared to have sufficient damages to justify a local protection project (LPP) shown in Plate R1, including:



N
Not Justified
LYNN BEACH
LYNN
Nahant Beach
LYNN HARBOR
Lynn LPP
SAUGUS
RIVER
POINT OF PINES
LPP-Separate Study
EAST SAUGUS LPP
SHUTE BK.
Railroad
PINES RIVER
REVETMENTS AND RAISE WALLS
SAUGUS
I-95 Fill
Marsh
BROAD SOUND
WETLAND MITIGATION SITE
PONDING AREA, WALL AND DIKE
B & M
1A
Revere Beach
TOWN LINE BROOK LPP
REVERE BEACH BACKSHORE LPP
1
Northgate Area Not Justified
107
MALDEN
LINDEN BK.
MAINTAIN EXISTING SEAWALL
Northgate
PARK DIKE
99
CREATE CLAM FLAT
ROUGHANS POINT
REVERE
TOWN LINE BK.
TIDE GATE
1
SALES CR.
BELLE ISLE
Broadway
LEGEND
New Dike and Wall Alignments
Existing Walls
1 - MILE
Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
Option #1
FOUR LOCAL PROTECTION PLANS
USArmy
Corps Of Engineers
New England Division
June 1989

PLATE R-1

1. Revere Beach Backshore, Revere
2. City of Lynn
3. East Saugus, Saugus
4. Town Line (and Linden) Brook, Revere and Malden
5. Northgate Area, Revere

The Point of Pines area is not included in Option 1 since it has its own approved Local Protection Plan and by letter the city advised the Corps it could not be funded, thus it is not likely to be built in the future. In the remaining two areas of the Upper Saugus River, (including Shute Brook) Area and the Estuary Area, buildings and damages are too spread out along river banks and roadways to warrant consideration for a separate local protection plan. However, their buildings would be evaluated for nonstructural measures. On the Upper Saugus River and Shute Brook, only 16 buildings along 2,000 feet of riverbank are directly affected by the 100 year tide level. The remaining buildings in these areas are above that level with drainage or river runoff problems influenced by high tides. During the investigation, the committees and general public identified extensive areas above tide levels where damages were made worse by high tides causing drainage systems to backup. However, the complexity of attempting to quantify the many problems was beyond the scope and resources of the study.

Around the estuary, there are about 20 buildings. Twelve are spread along 1,500 feet at the outer point of Oak Island and the remainder are scattered around the estuary. Thus, the six geographic areas being considered for LPP's contain all but about 36 buildings directly affected by tidal flooding. The following section describes the formulation and feasibility of the areas for local protection plans.

OPTION #1 CRITERIA

Preliminary Plans - Preliminary level detail was used for the initial screening of all plans. This level of detail involved selecting a representative section for each reach of shorefront and preparing reasonable designs to reduce overtopping. A contingency of generally 25 to 35 percent was used on all cost estimates. Any recommended plan would undergo additional refinements in design and the contingency would generally be reduced. A wide variety of alternative and cost estimates and benefits were developed.

Design 500 yr stillwater levels: The best available information for Broad Sound and river water levels were developed by the Corps' Waterways Experiment Station tidal model and were used for the design of dikes and walls. The design 500 year stillwater levels provided by the model are:

LOCATION	500 YR. STILLWATER TIDE LEVELS EL. (FT. NGVD)
Broad Sound at Revere Beach & Lynn Harbor	EL. 11.2 (similar to Boston)
Pines River, Conflu. to B&M Bridge	EL. 11.3
Pines River, B&M to Rt. 107	EL. 11.7
Pines River, 107 to both sides of I95 fill	EL. 11.9
Saugus River, Downstream of Rt. 107	EL. 11.3
Saugus River, Upstream of Rt. 107	EL. 11.5

Height of Dikes and Walls - The height for earthen dikes in coastal areas subject to wave attack were based on an analysis of wave run-up conditions. Unless dikes are designed to withstand overtopping, the crest should be set above the level of expected wave run-up Around the estuary shallow water waves generated under storm conditions could reach about 1.5 feet in height and could produce run-up of about 2 feet above the design stillwater level. An additional 3 feet should be added for earthen dikes to account for any uncertainty in the analysis and is recommended to assure that significant wave overtopping and failure of the dike does not occur. If earthen dikes are designed to take some wave overtopping, a crest height 3 feet above design stillwater level is appropriate.

The height of earthen dikes located in areas that are not subject to wave conditions, generally on the Saugus River above Route 107, were set to account for the uncertainties of concurrent Riverine flow with ocean storm surge conditions. A crest height 3 feet above design stillwater level was used.

Earthen dikes located in built up areas that are neither subject to wave attack nor adjacent riverine flows (such as areas subject to overland flooding) should have crests set 3 feet above design stillwater level to account for uncertainties in the method of overland flow analysis.

Concrete walls in the coastal zone can withstand significant wave overtopping. Therefore, due to small waves in the backshore area, a crest two feet higher than design stillwater level was used. In areas not subject to waves, a 2 foot increase above design stillwater is appropriate to account for uncertainty in design stillwater levels.

Stone Protection for Earth Dikes - Along the banks of both the Pines and Saugus Rivers dikes designs would include stone protection to protect the earth fill from currents and wave action.

Along the marsh where dikes are, almost without exception within the intertidal zone, ground elevation at and below EL. 7.5, they are also exposed to a shallow wave. The marsh with an elevation of about EL. 5 would have water depths of 5 to 6 feet deep for the 500 year design storm. For anticipated wind velocities, short period "erosive" choppy-type waves generally 1 to 1.5 feet high would occur. For historical storms, winds have occurred during flood tides in the direction of all proposed marsh dike alignments. Besides the potential erosive action of waves a major consideration is the observed activity of dirt bikes on the I-95 fill and thus potential erosion on the surface.

All dikes exposed to the shallow wave, subject to frequent inundation and scour and dirt bike activity were protected with a rock layer. This would also reduce problems down the road for communities maintaining scoured sections of earth/grass exposed dikes. The rock would provide a higher level of certainty the dikes would not fail in the long term.

REVERE BEACH BACKSHORE LPP

The Revere Beach Backshore Area, shown on Plate R2A was divided into subareas from 1 to 5D for evaluating flood levels and damages, as previously explained. The separate areas also helped in determining the economic feasibility of including them in a separate plan. The shorefront is divided into reaches "A" through "K" for describing and evaluating different types of improvements (e.g., walls, dikes, etc.) which would reduce overtopping. The following describes how plans were formulated.

INITIAL PLANS - A large number of plans were formulated at the start of this investigation in coordination with the MDC and the City of Revere in 1983 and 84 prior to refinement of tide levels and remodelling in 1985/86. The following summarizes a description of each plan and net benefits updated after tide levels were established on the Saugus and Pines Rivers. Table B-1 summarizes each plan, its design storm level to reduce overtopping and damages and their net economic benefits. A major concern for Revere Beach is the stability of the two sections of beaches at Reaches A and C. These two sections were not overtopped in 1978 and the analysis of wave run-up on their existing beach surfaces during 100 year, 500 year and SPN tide conditions showed their seawalls should not be overtopped. The concern was whether the beach would erode in the future or during the severe storm events. Addendum 3 includes an investigation on the stability of Revere Beach to withstand future coastal storms. It discusses results of a workshop and analysis by Dr. W. Frank Bohlen, Consultant and Oceanographer, Department of Marine Science, University of Connecticut. Dr. Bohlen had investigated Revere Beach oceanography and sand movement on several occasions. To summarize, these two sections (A and C) have been stable since the beach was first surveyed in 1900 and can be expected to remain stable in the future. Also during the 1978, 100 year flood, there was very little erosion of the beach to affect overtopping due to the low wave energy dissipated at these two locations. Recurring storms of similar or greater magnitude should not result in significant beach erosion or overtopping.

Plans A1 to A4 included widening the authorized beach from the 50 foot berm width scheduled to be built for the Revere Beach Erosion Control Project. For reaches "B" and "D" the beach sections prone to high wave energy and erosion, the berm (or flat part of the beach nearly level with the Boulevard) would need to be about 150 to 250 feet wide for 100 year to SPN protection, respectively.

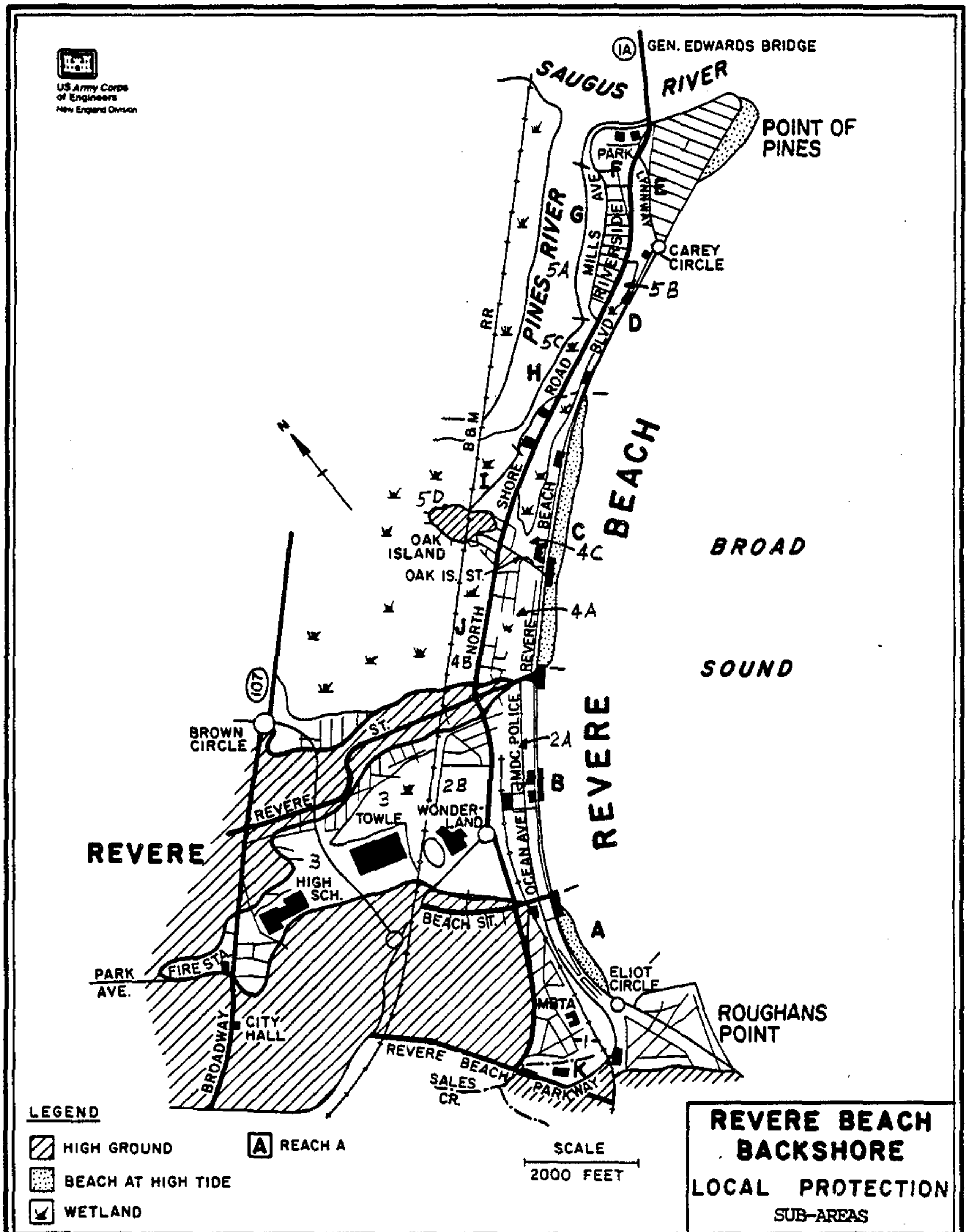

US Army Corps of Engineers New England Division
GEN. EDWARDS BRIDGE
1A
SAUGUS RIVER
POINT OF PINES
PARK
MILLS AVE
RIVERSIDE
LYNNWAY
CAREY CIRCLE
PINES RIVER
RR
B&M
ROAD
BLVD
SHORE
BEACH
NORTH
REVERE
REVERE BEACH
BROAD SOUND
OAK ISLAND
OAK IS. ST.
5A
5B
5C
5D
4A
4B
4C
2A
2B
3
BROWN CIRCLE
107
ST.
REVERE
MDC POLICE
OCEAN AVE
TOWLE
WONDERLAND
REVERE
HIGH SCH.
BEACH ST.
PARK AVE.
FIRE STA.
BROADWAY
CITY HALL
REVERE BEACH PARKWAY
SALES CR.
MBTA
ELIOT CIRCLE
ROUGHANS POINT
A
B
C
D
E
F
G
H
I
J
K
LEGEND
HIGH GROUND
BEACH AT HIGH TIDE
WETLAND
A REACH A
SCALE
2000 FEET
REVERE BEACH BACKSHORE
LOCAL PROTECTION
SUB-AREAS

PLATE R-2A

A "levee" refers to shorefront protection for reaches "E" to "J" along the Pines River and Marsh. The lowest cost structure was used for the levee in evaluating these plans among the walls, dikes, and road and railroad raising options considered separately, Reach "G" used a wall at the guardrail of Mills Avenue along the Pine River. Reaches "F", "H" and "I" used earth dikes along the edge of Gibson Park (Route 1A to the Pines River), along Route 1A at the riverbank and the old narrow gage R.R. bed. Reaches "E" (SPN only) and "J" used a combination of walls and dikes behind homes on the Lynnway and bordering the B&M R.R. tracks.

As shown for the following "Initial Plans", Plans A1 and A2 were not justified. A3 and A4 with a widened beach at reach B at either the 100 or 500 year level and the levee were justified. The wall in Reach "K" to stop flooding from Suffolk Downs was far too costly compared to its benefits.

Plans B1-3 include raising of a park embankment between Ocean Avenue and the Boulevard behind Reach B to stop water overtopping the seawall from reaching developed area. This is also the proposal in the Master Plan for the Reservation. The widened beach in Reach "D" was used to reduce overtopping for the SPN event in Plan B1, but was not found feasible.

OPTION 1 - REVERE BEACH BACKSHORE LPP
INITIAL PLANS

Plan	Description	Level of Design Storm	Preliminary Net Economic Benefits ($1,000/year)
A1	Beach @ B&D, Levee, Wall @ K	SPN	(-$675)
A2	Beach @ B&D, Levee	SPN	(-$494)
A3	Beach @ B, Levee	500 yr.	$271
A4	Beach @ B, Levee	500/100 yr.	$205
B1	Dike @ B, Beach @ D, Levee	SPN	(-$103)
B2	Dike @ B, Levee	500 yr.	$489
B3	Dike @ B, Levee	100 yr.	$426
C	Step Wall @ B, Levee	500 yr.	(-$970)
D	Breakwater @ B, Levee	500 yr.	(-$1058)
E	Revetment @ B, Levee	500 yr.	(-$167)
F	Dike @ B, Revetment @ D, Levee	SPN	(-$182)

Economic Comparison - A Plan B2 was found to produce the highest net economic benefits at the 500 year level with the dike at "B" and the levee along the river. The small amount of water estimated overtopping reach "D" for the 100 and 500 year events would cause very little damage and could be stored in the ponding area between the homes and Route 1A.

Plan C, D and E evaluated other measures in Reach B including a stepped concrete seawall, a breakwater offshore and an armor stone revetment to reduce overtopping, however they were not justified.

Plan F also looked at a revetment at Reach "D" which was not justified.

The results of the evaluation showed Plans B2 and B3 were the most feasible and warranted additional technical, social, environmental and economic evaluation.

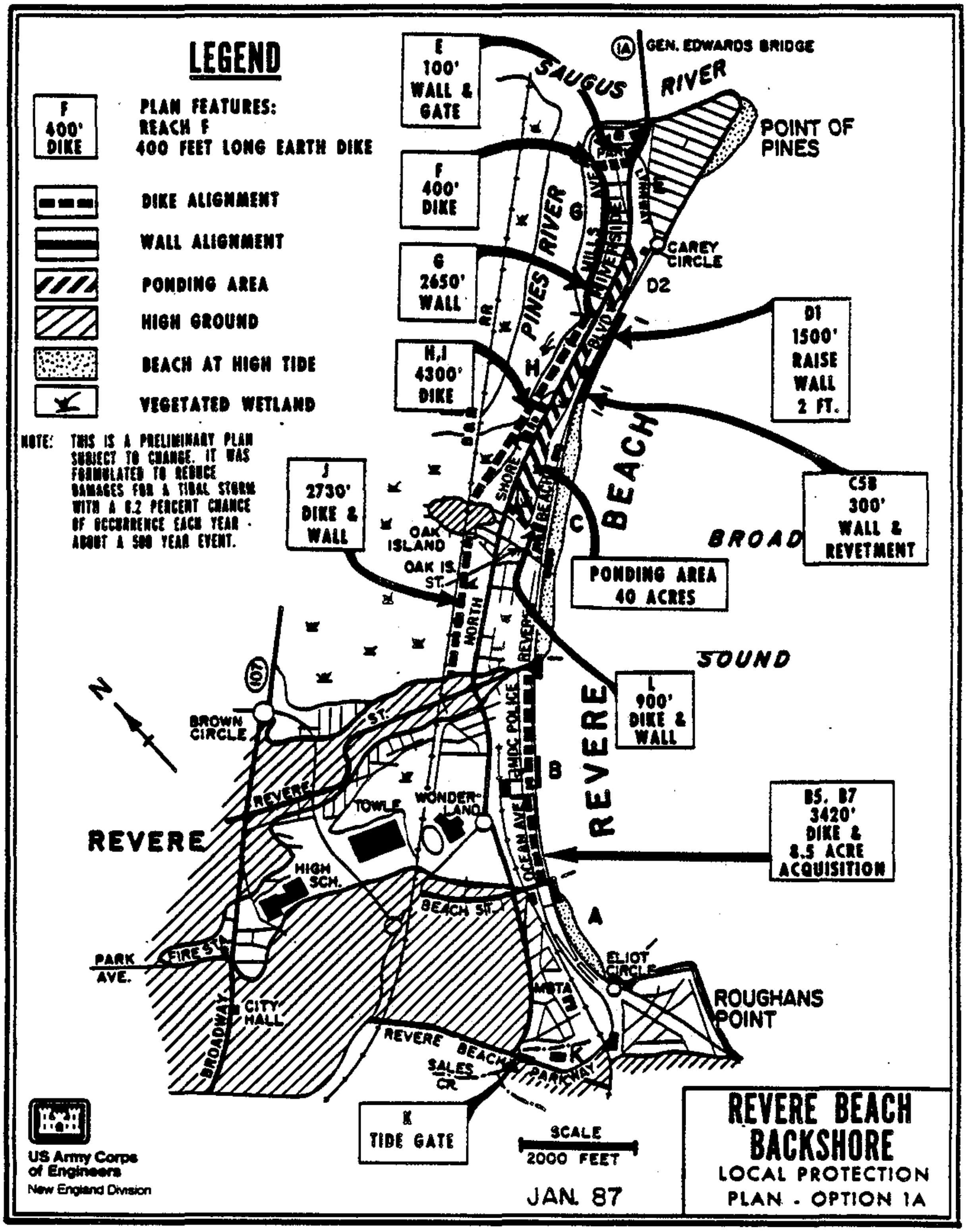
Initial Plan Refinements - Plan B2 was evaluated in more detail in 1984 and '85 during development of local protection plans for the regional Study. The results were provided for coordinating with the Citizens Steering committees and Technical Group in a Project Information Binder along with providing them all Project Correspondence. The preparation of Plan B2 at the 500 year level was evaluated by Corps biologists and the U.S. Fish and Wildlife Service. Comments were also received from community officials and citizens along the reaches which helped to reformulate the plan and make them more acceptable (See Addendum #1). Adjustments were made in the alignments to reduce environmental impacts and two schemes were developed to compare economic costs versus environmental impacts.

Option 1A - depended primarily on earth dikes for the Pines River levee, similar to Plan B2. It was the lowest cost plan, but the dikes caused significant impacts on vegetated wetlands.

Option 1B - reduced the impacts on vegetated wetlands by replacing the dikes with walls but cost more.

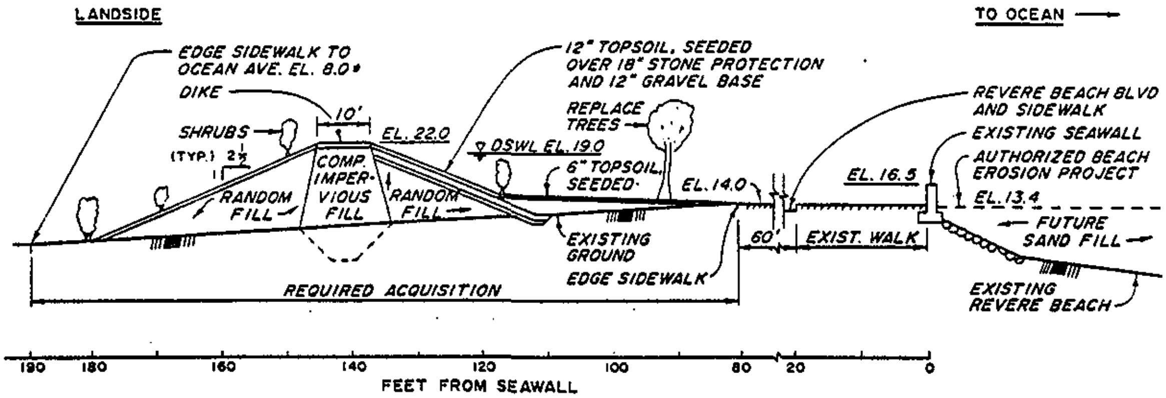
For both options, features were included to preserve a 40 acre ponding area behind Reach "D" with permanent easements, and to modify the Revere beach Reach "D" wall. The volume of water overtopping Reach "D" for the 500 year event was determined to be greater than the ponding area could store without creating worse damages. Therefore, the existing Revere Beach seawall in Reach "D" was raised two feet for 1800 feet of wall and a 300 foot long revetment was added to reduce the overtopping at the south end. The plan still included the park dike behind Reach B. Plates R2 through R6 reviewed by the committees show the plan and sections for Option 1A. The only differences in Option 1B were that dikes were replaced by walls in Reaches F, H, I, and J.

	Initial Impacted Veg. Wetlands	Initial Net Benefits ($1000)
Option 1A - primarily dikes	11 Acres	$ 820
Option 1B - primarily walls	5 Acres	$ 650



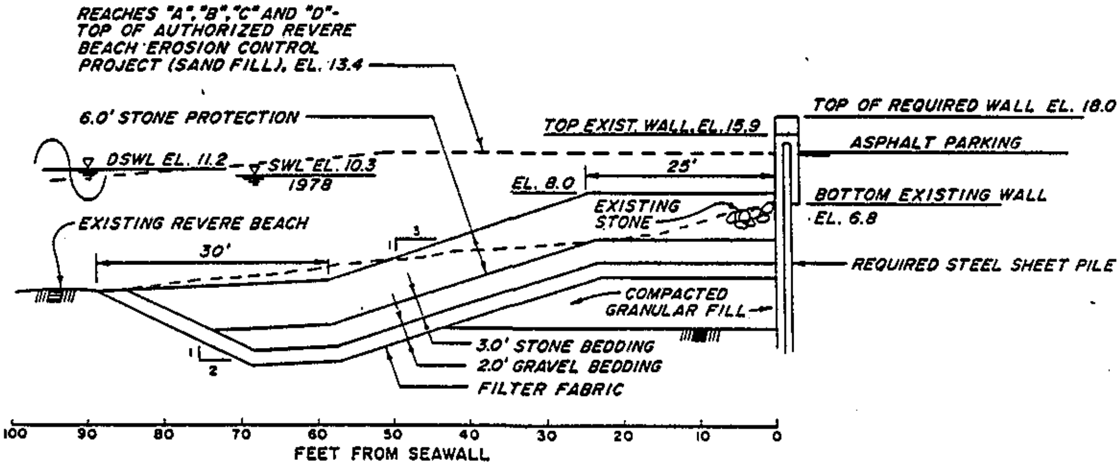
LEGEND
F 400' DIKE
PLAN FEATURES:
REACH F
400 FEET LONG EARTH DIKE
DIKE ALIGNMENT
WALL ALIGNMENT
PONDING AREA
HIGH GROUND
BEACH AT HIGH TIDE
VEGETATED WETLAND
NOTE: THIS IS A PRELIMINARY PLAN SUBJECT TO CHANGE. IT WAS FORMULATED TO REDUCE DAMAGES FOR A TIDAL STORM WITH A 0.2 PERCENT CHANCE OF OCCURRENCE EACH YEAR · ABOUT A 500 YEAR EVENT.
E 100' WALL & GATE
F 400' DIKE
G 2650' WALL
H,I 4300' DIKE
J 2730' DIKE & WALL
D1 1500' RAISE WALL 2 FT.
C5B 300' WALL & REVETMENT
PONDING AREA 40 ACRES
L 900' DIKE & WALL
B5, B7 3420' DIKE & 8.5 ACRE ACQUISITION
K TIDE GATE
GEN. EDWARDS BRIDGE
SAUGUS RIVER
POINT OF PINES
CAREY CIRCLE
PINES RIVER
RIVERSIDE
REVERE BEACH
BROAD SOUND
OAK ISLAND
OAK IS. ST.
BROWN CIRCLE
REVERE
TOWLE
WONDERLAND
HIGH SCH.
BEACH ST.
PARK AVE.
FIRE STA.
CITY HALL
BROADWAY
OCEAN AVE
ELIOT CIRCLE
ROUGHANS POINT
REVERE BEACH PARKWAY
SALES CR.
SCALE
2000 FEET
JAN. 87
US Army Corps of Engineers
New England Division
REVERE BEACH BACKSHORE
LOCAL PROTECTION PLAN - OPTION 1A

PLATE R-2

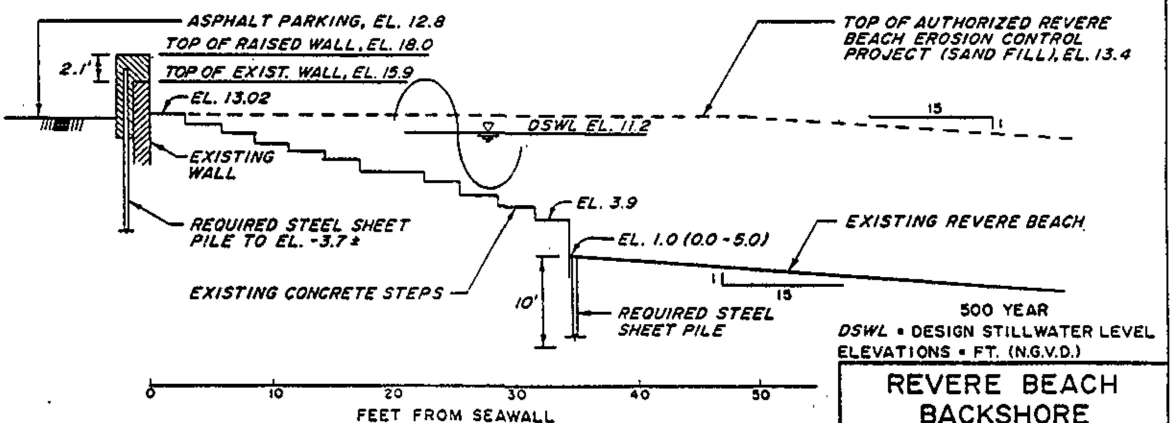


REACHES "B5" AND "B7" - M.D.C. PARK DIKE & 8.5 ACRES ACQUISITION

INCLUDES RAMP ON BLVD. AT SOUTH END OF DIKE NEAR BEACH STREET
AND A RAMP OVER DIKE AT NORTH SIDE OF POLICE STATION



REACH "C5B" - REVETMENT AND WALL



REACH "D1" - RAISE WALL

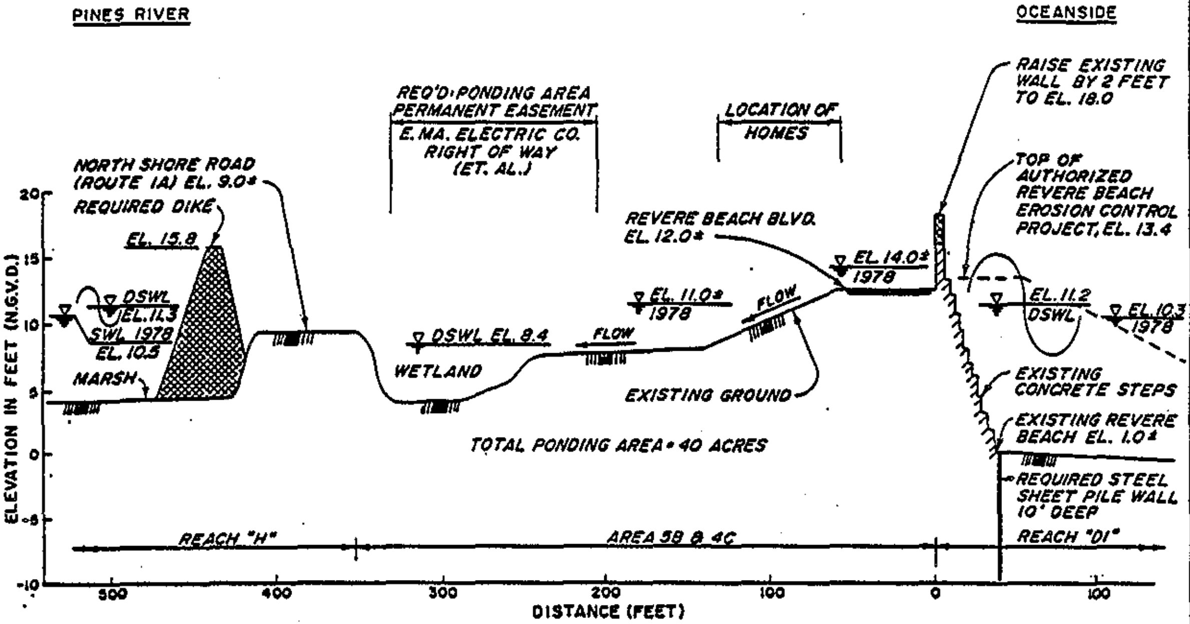
500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)

REVERE BEACH
BACKSHORE

LOCAL PROTECTION PLAN
OPTION 1A
SECTIONS

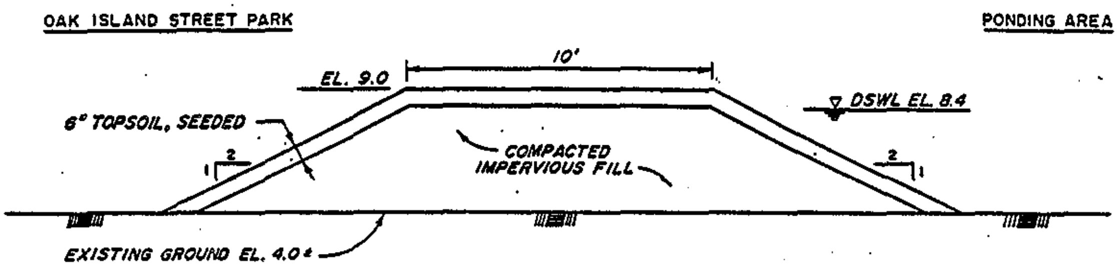
DECEMBER 1986

PLATE R-3

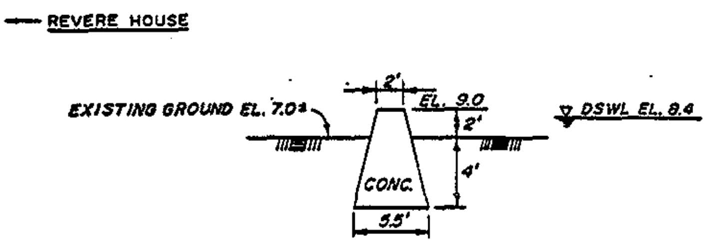


RAISE REACH "D1" WALL 2 FEET WITH SSP WALL AT BASE OF STEPS,
REACH "H" - EARTH DIKE,
AND NORTH SHORE ROAD - PONDING AREA – PERMANENT EASEMENT - 24 ACRES

REACHES A, B, C & D' MAINTAIN EXISTING SEAWALLS AND BEACH



REACH "L" - EARTH DIKE



REACH "L" - CONCRETE GRAVITY WALL

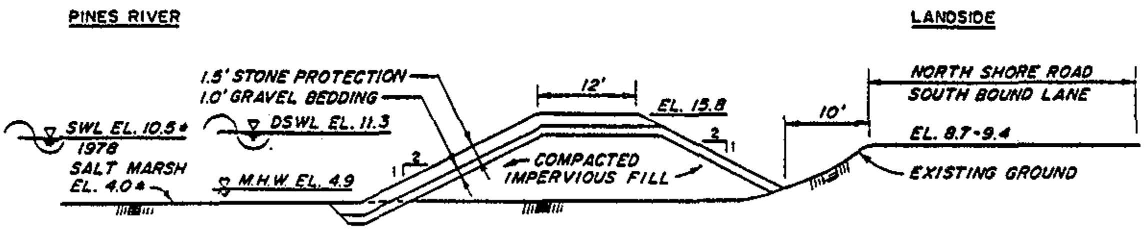
500 YEAR
DSWL • DESIGN STILLWATER LEVEL
ELEVATIONS • FT. (N.G.V.D.)

REVERE BEACH
BACKSHORE

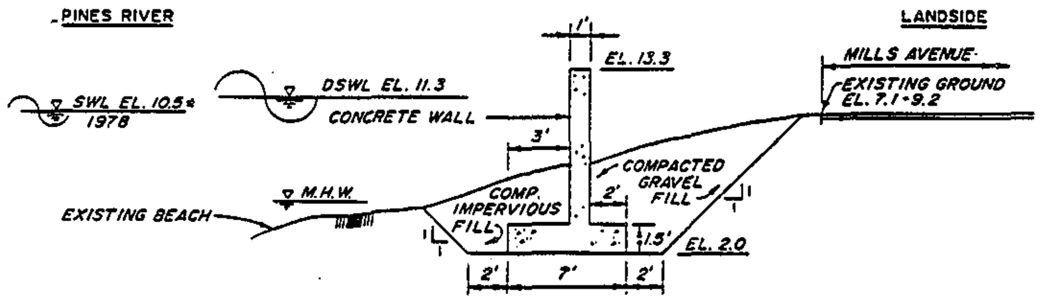
LOCAL PROTECTION PLAN
OPTION 1A
SECTIONS

DECEMBER 1986

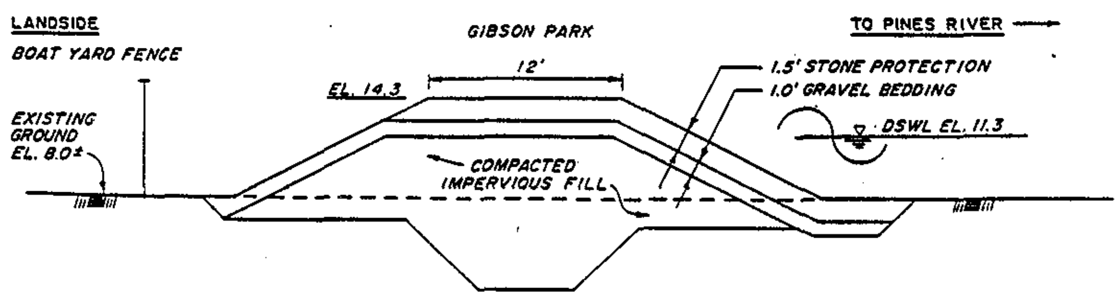
PLATE R-4



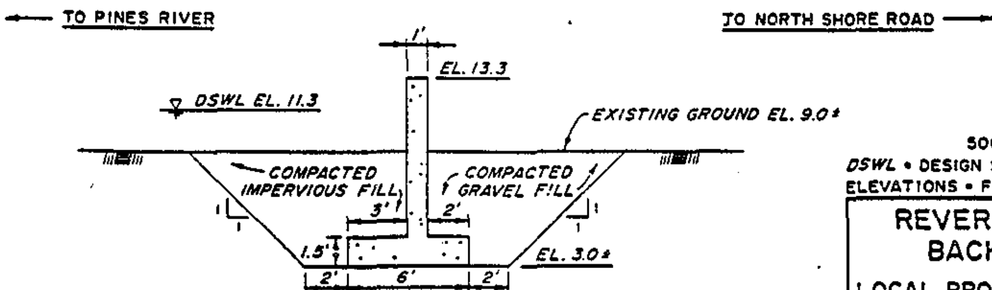
EARTH DIKE - REACH "H"



CONCRETE "T" WALL - REACH "G"



DIKE - REACH "F"



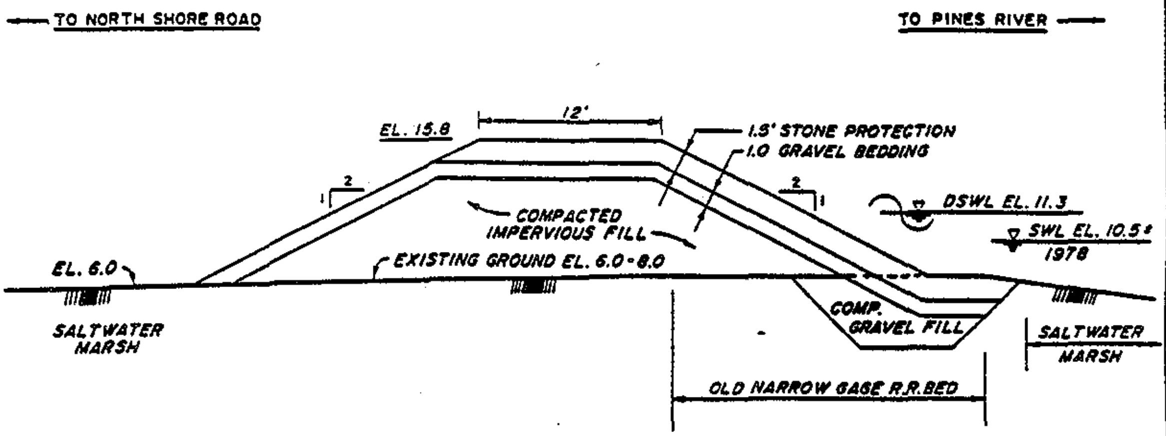
CONCRETE "T" WALL - REACH "E2"

500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)

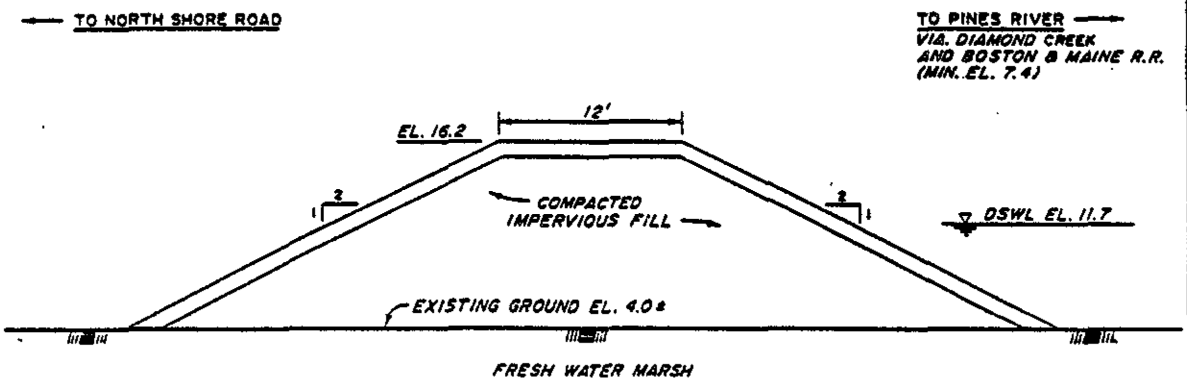
REVERE BEACH
BACKSHORE

LOCAL PROTECTION PLAN
OPTION 1A
SECTIONS
DECEMBER 1986

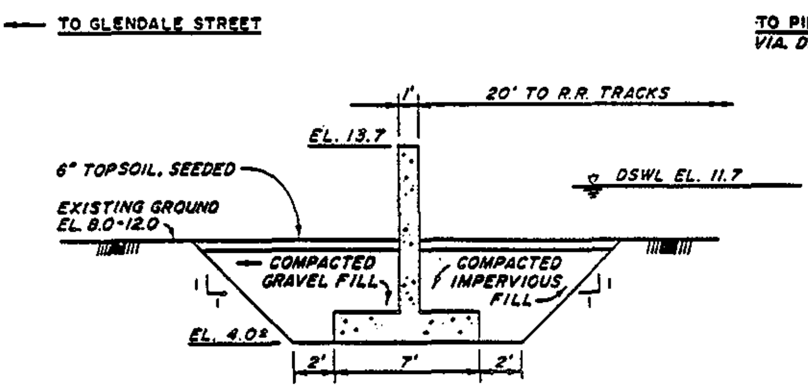
PLATE R-5



REACH "I" - EARTH DIKE
WITH TIDE GATE AT DITCH



REACH "J2" - EARTH DIKE
WITH TIDE GATE AT DIAMOND CREEK



REACH "J1" - CONCRETE "T" WALL ON OAK ISLAND

500 YEAR
DSWL • DESIGN STILLWATER LEVEL
ELEVATIONS • FT. (N.G.V.D.)

REVERE BEACH
BACKSHORE

LOCAL PROTECTION PLAN
OPTION 1A
SECTIONS
DECEMBER 1986

PLATE R-6

In each case the impacted vegetated wetlands were half salt water marsh and half fresh water marsh.

There was support for a local protection plan from the Revere Conservation Commission. However, state and federal resource agencies and environmental interest groups were very much concerned for the loss of vegetated wetlands from either plan. The cost difference between the two plans was $1.7 million higher for Option 1B, excluding mitigation costs.

Initial Plan Revised - There was extensive public involvement which followed with Federal, state and local officials and the five Committees from October 1985 to June 1988. During that time it became very apparent that no plan which significantly damaged vegetated wetlands, would be totally supported. Consequently, both plans were reviewed and costs updated with some modifications to the design of walls accomplished. The addition to the plan was a 230 foot long revetment wrapping around Carey Circle at the north end of the Revere Beach Reservation. This revetment would have been built with the Point of Pines LPP had the project proceeded to construction. Adjustments were made in the alignment of the park dike and a stone layer placed beneath the grassed slope to prevent scouring and breaching of the dike. The cost estimate was also revised for 1988 price levels, and real estate values adjusted. Contingencies were adjusted to reflect uncertainties in design such as unknown foundation conditions, stability of existing shorefront structures and future developments along the Pines River which may affect project alignments and changes in designs and quantities of materials and unit prices. Benefits were also updated and explained later. Since the loss of wetlands can be mitigated at a lower cost, Option 1A, primarily dikes, was selected over Option 1B to represent the Local Protection Plan - Option 1.

Plan Description - The Plan requires 3.1 miles of new structures as explained below. They would reduce flood damages to 1,200 buildings, and require maintenances of an additional 2.4 miles of existing shorefront, and also provide for recreation.

Reach "A" - The existing Revere Beach and seawalls between Eliot Circle and the Beach Street Pavilions were not overtopped in 1978. Run-up analysis on the beach and seawalls indicate there would be no overtopping even for the SPN event, with one foot of sea level rise. Historically, the beach has been building up over the years and erosion is not a problem in this Crescent Beach Area. Therefore, no improvements are required. It is assumed, the Roughans Point Project would be built. It includes a revetment at Eliot Circle and south along the Roughans Point shorefront to significantly reduce wave overtopping. Beach erosion at the southern half of the rotary allowed overtopping which entered Roughans Point, with very little water entering the Study Sub-area #1. The revetment would reduce the amount of water reaching Area #1.

Reach "B" - Extensive overtopping occurs from north of Beach Street to the Revere Street Pavilion #5 due to the eroded condition of the beach.

Reaches "B5" & "B7" - MDC Park Dike - The most economically feasible and acceptable option was raising the MDC park land behind the wall. Reaches B5 and B7 are vacant park land from Beach Street to Revere Street, bounded by Ocean Avenue and Revere Beach Boulevard, except for the MDC Police Station and bath house. The Master Plan for the reservation also includes raising the parkland.

This feature called the MDC Park Dike would be constructed high enough so that water overtopping the existing seawall would flow back out over the wall. Also included is a ramp on the Boulevard at the south end of the dike to contain the water. Retaining walls would be built to tie the dike into each side of the police station. At the north side of the station, a ramp would pass over the dike for police access. Other features included in the Master Plan for safety, recreation, aesthetics, drainage, access to the park and protection of the embankment will be evaluated during detailed planning. There are 8.5 acres of park land needed for this Federal Project that are owned by the MDC.

Reach "C" - The existing Revere Beach wall along Reach "C" also was not overtopped in 1978 nor should it be in the vent of an SPN, with one foot of sea level rise. Historically the beach has remained stable and no change is expected. The authorized project will help to assure its stability. No improvements are required in the Reach.

Reach "C5B" - The north end of Reach "C" has eroded of a distance of about 300 feet probably due to the concrete stepped structures in Reach D1. To reduce the overtopping in the reach a wall 2 feet higher is needed with an armor stone revetment at the base of the wall to break waves.

Reach "D1" - The 1500 feet wall and concrete steps in this reach were significantly overtopped in 1978. Raising the existing wall by 2 feet would substantially reduce the overtopping and damages to homes along the Boulevard — provided that the existing 40 acre ponding area behind the homes is preserved for water which would continue to overtop the seawall.

No improvements are required in Reach D2. The authorized beach project would help prevent deterioration of the beach. The stability of the walls, however, in Reaches D1 and D2 to withstand severe coastal storms would require further design evaluation if the project were selected. Any failure of these walls could cause catastrophic flooding during severe coastal storms, since there would be only a limited amount of storage between the Boulevard and the required walls and dikes along the Pines River.

Reach "D3" - The 230 foot stretch around the base of the seawall at Carey circle was significantly overtopped in 1978. The water flowed south along the Boulevard, west across North Shore Road and north down the Lynnway. A revetment would substantially reduce this overtopping.

Ponding Area and Reach "L"

To assure that most of the storage remains available in the existing ponding area, strict wetland enforcement would be required. Most of the ponding area is an existing ditch running between the house lots and North Shore Road. Most of the land belongs to Eastern Mass. Electric Company. The area runs about a mile from the Oak Island Street Park to properties behind Carey Circle.

A dike is required in Reach "L" to contain water in the ponding area. It runs along the edge of the park from North Shore Road to the parking area of the Revere House; a wall continues to high ground. Typical cross sections are shown in Plate R4 for the Reach "L" dike and wall, and for the location of the ponding area in relation to Revere Beach and the Pines River.

Reach "E" - includes Lynnway which runs from Carey Circle to North Shore Road. Without the Point of Pines Project some overtopping of Lynnway would occur. A 100 foot section of wall and gated closure in Reach E2 will be needed at the underpass of North Shore Road to prevent water from the Pines River from flowing into the protected area.

Reach "F" - includes a wall running along the SE edge of Gibson Park. Structures from Reach "E2" to "J2" are needed to prevent high tide levels in the Pines River from flowing into the protected areas.

Reach "G" - includes a wall running along the edge of the Pines River or beach adjacent to Mills Avenue. Residents preferred the wall in lieu of a dike to reduce the loss of their beach. The low wall at the guardrail has a similar cost as a more massive dike.

Reach "H" and "I" - run along the edge of the riverbank and old narrow gauge railroad bed. A dike would tie to high ground on Oak Island. Other alternatives included a wall along the riverbank, raising one or both lanes of North Shore Road and a wall down the median strip and either side of the road.

Reach "J" - continues from high ground on Oak Island with a wall at the edge of the railroad right-of-way. A closure is needed at Oak Island Street for Reach "J1". Reach "J2" continues across the fresh water marsh with a dike adjacent to the railroad embankment, tying to high ground behind homes near Revere Street. An alignment along the North Shore Road embankment was evaluated, however it would interfere with potential development for the area. A tide gate is included where "J2" crosses the county ditch to Diamond Creek. A wall was evaluated in Option 1B.

Reach "K" - The Revere Beach Parkway is high enough to prevent flood waters in Suffolk Downs from flowing into the area up to a 100 year 1978 event. A tidegate must be included on Sales Creek where it passes under the Parkway. This is the highest level of protection which could be justified.

Mitigation - Project Costs include the mitigation of 3.9 acres of intertidal habitat by replacing the loss in kind by removal of I-95 fill for creating clam flats. The 6.6 acres of mitigated wetland lost includes removal of 7.3 acres of I-95 fill to create wetlands. The acreage mitigated is 10 percent higher than acreage lost in order to offset the recovery time of the wetlands.

The plan also includes four new gated closures and existing stop-log closures along Revere Beach for recreation access. Along the Pines River three large and several smaller sluice gates must be closed for the plan to function during a storm.

Project average annual benefits include recreation benefits, and reduction of: flood damages to buildings, shorefront structures damage, damages from sea level rise, damages to future development, emergency costs, flood insurance and other costs.

Flood Damage Reduction - The project would substantially reduce existing average annual damages to about 1200 buildings.

Shorefront damages - The project would eliminate future replacement and repair costs of existing shorefront structures along the Pines River. The reduction in the replacement and repair costs of existing shoreline structures results from an elimination of those structures (and future costs) replaced by project features. Along the Pines River, walls would eliminate the need to constantly maintain existing walls and rip rap or shoreline from eroding due to coastal flooding and daily tidal action. New walls would protect the shore in place of existing shoreline structures.

The park dike would provide a passive recreation area for an estimated 121,000 activity days per year.

Flood damage reduction due to sea level rise is included and is based on the future average annual reduction in flood damages from a gradual rise (historical rate) in relative sea level. The plan was optimized at the 100 year level of protection as shown below.

OPTION 1A
REVERE BEACH BACKSHORE LPP
BENEFITS, COSTS AND ECONOMIC ANALYSES - SUMMARY (88, P.L.)

	PLAN:		
	100 yr	500 yr	SPN
Project First Cost ($1000)	$21,190	$23,620	$26,440
Project Benefits ($1000)	2,431	2,583	2,639
Project Average Annual Cost ($1000)	2,356	2,620	2,926
Net Benefits ($1000)	75	-37	-287
Benefit-to-Ratio:	1.03	0.9	0.9

ENVIRONMENTAL IMPACTS

The project would impact on the following acres of property:

Type of Land	Option 1A (Acres)
Developed	1.0
Open Space, recreation	11.0
Vegetate Wetlands Lost	6.6
Intertidal Habitat Lost	3.9
Total Acres (Excludes Ponding Area)	22.5

The construction of walls and dikes would affect significant resource lands in the project area. The most significant impacts are:

Developed Land - Included are the wall alignment on Oak Island, within the railroad right-of-way, and the wall and dike in Reach L bordering residential property.

Open Space and Recreation - Construction of the MDC park dike would affect about 9.4 acres of land by converting 8.5 acres of existing relatively unused parkland to much improved parkland.

Gibson Park would be affected by construction of a wall bordering the park and marina.

Vegetate Wetlands Lost - The total acreage shown results from construction of dikes along the Pines River.

Intertidal Habitat Lost - The impacts result form construction of Revere Beach (Reach "C5B", "D1" and "D3") and along the Pines River in Reaches "G" and "H".

Visual and Other Impacts - Visual impacts can be expected along several of these reaches as structures are four to six feet above the ground in residential and commercial areas, and along Route 1A. Along Revere Beach the raising of 1800 feet of wall would restrict the view of the ocean from the Boulevard.

Noise, dust and other construction impacts could affect the area during construction.

PUBLIC VIEWS - The following are comments received on certain features of the local protection plan.

- MDC and Revere officials agree on keeping the Master Plan in the MDC Park area, that is, they support the parkland dike.
- Riverside residents interviewed prefer walls along Mills Avenue rather than dikes.

- One city official suggested that Reach "J" alignment be located adjacent to the railroad embankment as shown, rather than along North Shore Road, due to potential development in the area.

- Letters and comments received from most interests commenting on the plans, preferred the Regional Floodgate Plan (Option 3) rather than Local Protection Plans (Option 1) due to:

  - less impact on the wetlands
  - less impact on residential and commercial properties
  - lower cost and easier financing and implementation through State assistance.

CITY OF LYNN LPP

<u>Initial plans</u> - The coordination of plans in Lynn was accomplished with the Lynn Citizen Steering Committee. During the preparation of initial plans, the Corps project manager also interviewed and discussed alignments and future plans with property owners along Lynn Harbor, Lynn Beach and the Saugus River. The Lynn local protection area was divided into flood zones 1 to 5 and the shorefront into reaches A to R.

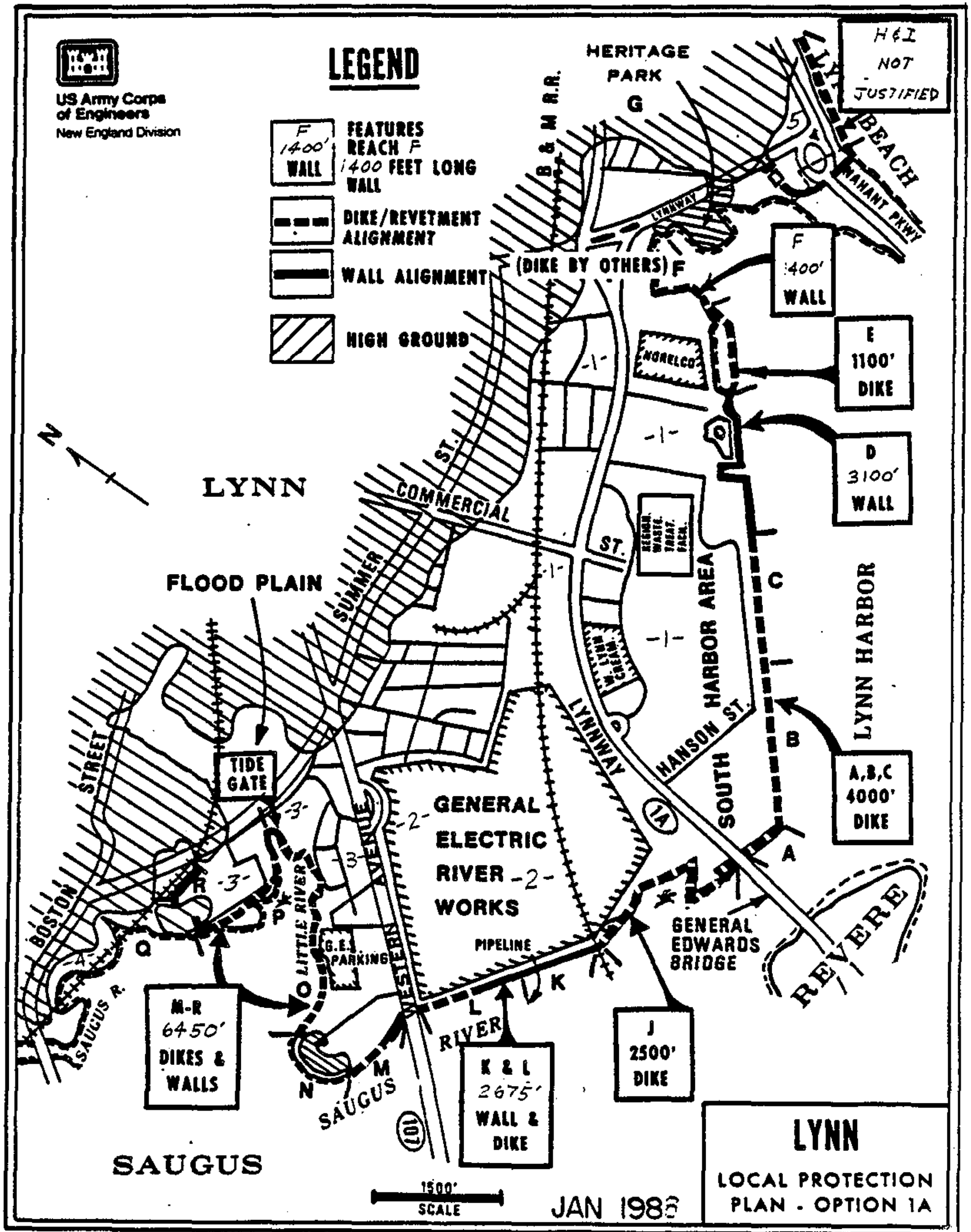
<u>Plan Description</u> - The Lynn LPP includes protection of about 1200 residential, public, commercial and industrial buildings. Generally, earth dikes with stone facing, concrete or steel sheet pile walls or armor stone revetments would be required along 4.2 miles of Lynn Harbor, Lynn Beach and the Saugus River shorefronts Plates R-7, R-8 and R-9 include plans and section for Option 1A.

<u>Initial Lynn Harbor Alignments</u>

Reaches "A", "B", and "C" - include an earth and stone face dike along the waterside of the existing Lynn Harbor bulkhead. This is a similar feature to that envisioned for the South Harbor Development Plan. the dikes would dissipate wave action and prevent water from flowing into the area. To reduce the impact on mudflats fronting the wall, an alternate alignment was considered which overlapped into the undeveloped land. However, the real estate cost for the loss of the undeveloped land was considerable. A steel sheet pile wall with a concrete cap would cost in excess of $5 million more than the dikes.

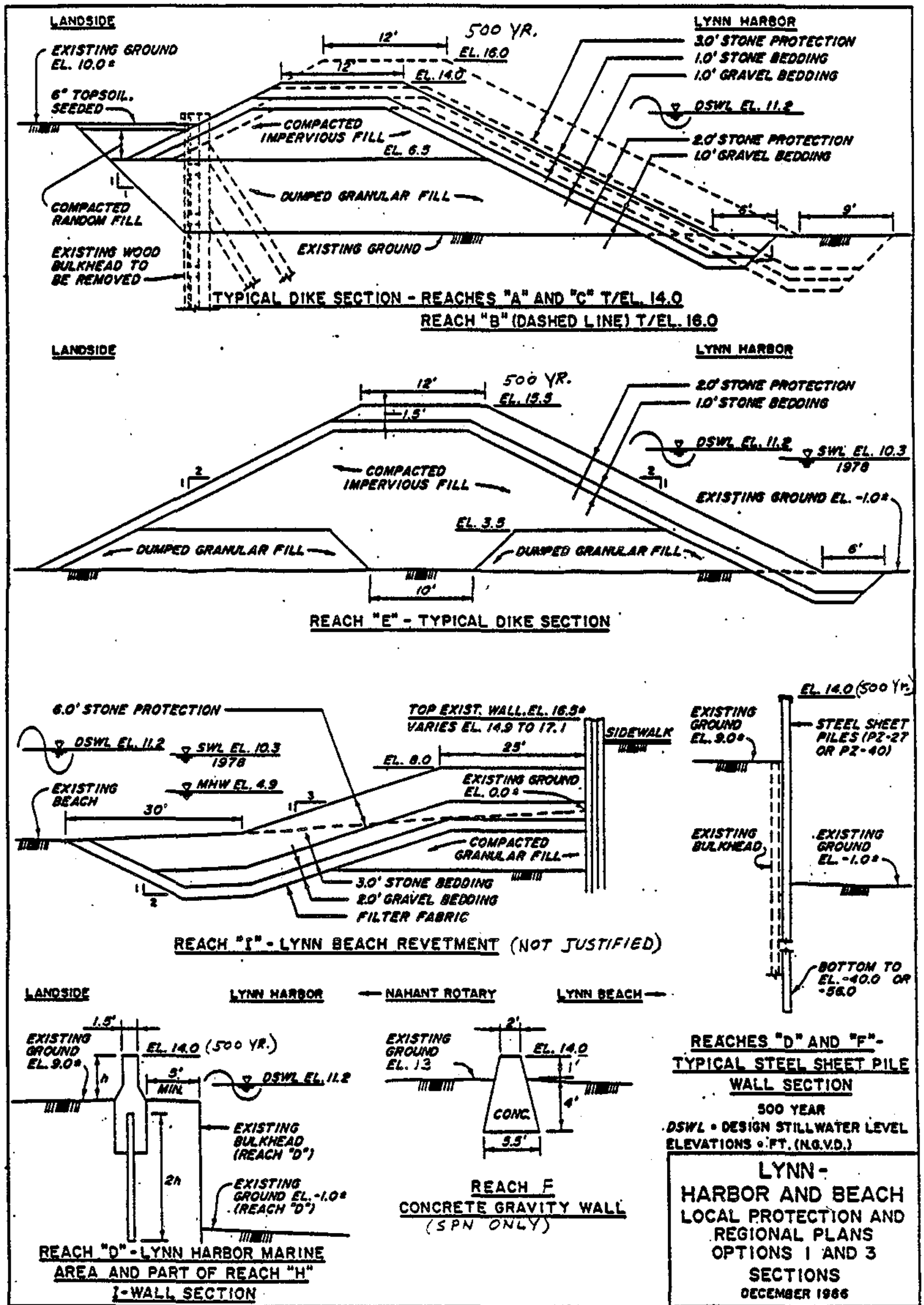
Reach "D" - includes steel sheet pile walls for replacing and/or raising existing timber, granite and steel bulkheads to reduce wave overtopping. The alignment is adjacent to marine-related activities. The owners requested that walls be used in lieu of dikes to prevent eliminating the use of boat moorings and impacting navigation for existing and future conditions.

Reach "E" - includes an earth dike along the shoreline of commercial and industrial lands. The owners indicated they may eventually develop their properties to their outer limits. The future status of their



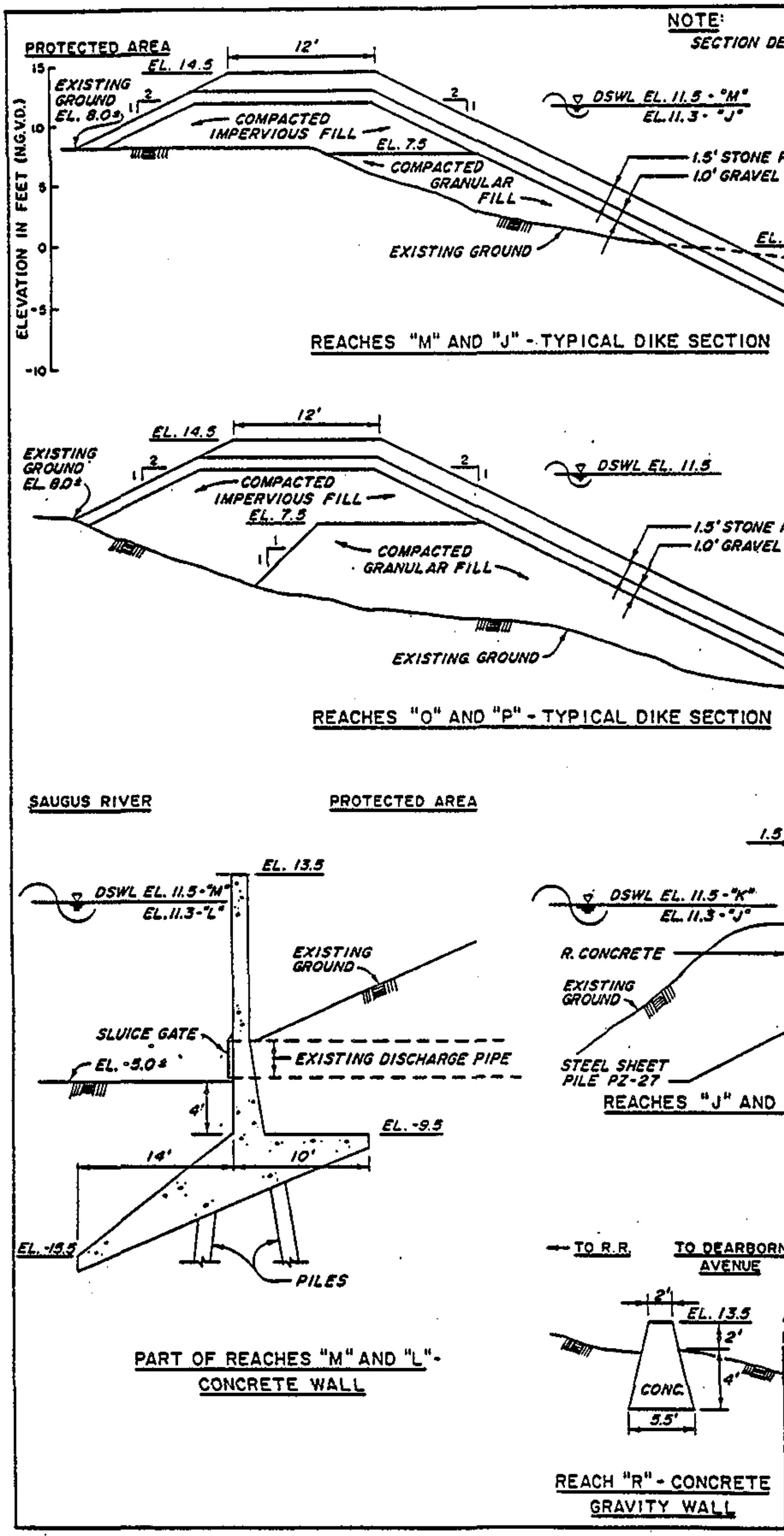
US Army Corps of Engineers
New England Division
LEGEND
F 1400' WALL
FEATURES REACH F 1400 FEET LONG WALL
DIKE/REVETMENT ALIGNMENT
WALL ALIGNMENT
HIGH GROUND
HERITAGE PARK
G
H & I NOT JUSTIFIED
LYNN BEACH
NAHANT PKWY
B & M R.R.
LYNNWAY
(DIKE BY OTHERS)
F
F 400' WALL
NORELCO
E 1100' DIKE
D 3100' WALL
LYNN
COMMERCIAL ST.
SUMMER ST.
C
FLOOD PLAIN
HARBOR AREA
LYNN HARBOR
HANSON ST.
SOUTH
B
A,B,C 4000' DIKE
TIDE GATE
BOSTON STREET
GENERAL ELECTRIC RIVER WORKS
WESTERN AVENUE
1A
A
R
P
Q
LITTLE RIVER
G.E. PARKING
PIPELINE
GENERAL EDWARDS BRIDGE
REVERE
K
L
M-R 6450' DIKES & WALLS
O
SAUGUS R.
N
M
SAUGUS RIVER
107
K & L 2675' WALL & DIKE
J 2500' DIKE
SAUGUS
1500' SCALE
JAN 1983
LYNN
LOCAL PROTECTION PLAN - OPTION 1A

PLATE R-7



LANDSIDE
LYNN HARBOR
500 YR.
12'
EL. 16.0
12'
EL. 14.0
EXISTING GROUND EL. 10.0±
6" TOPSOIL, SEEDED
3.0' STONE PROTECTION
1.0' STONE BEDDING
1.0' GRAVEL BEDDING
DSWL EL. 11.2
COMPACTED IMPERVIOUS FILL
EL. 6.5
2.0' STONE PROTECTION
1.0' GRAVEL BEDDING
COMPACTED RANDOM FILL
DUMPED GRANULAR FILL
6'
9'
EXISTING WOOD BULKHEAD TO BE REMOVED
EXISTING GROUND
TYPICAL DIKE SECTION - REACHES "A" AND "C" T/EL. 14.0
REACH "B" (DASHED LINE) T/EL. 16.0
LANDSIDE
LYNN HARBOR
12'
500 YR.
EL. 15.5
1.5'
2.0' STONE PROTECTION
1.0' STONE BEDDING
DSWL EL. 11.2
SWL EL. 10.3 1978
COMPACTED IMPERVIOUS FILL
EXISTING GROUND EL. -1.0±
EL. 3.5
DUMPED GRANULAR FILL
DUMPED GRANULAR FILL
6'
10'
REACH "E" - TYPICAL DIKE SECTION
6.0' STONE PROTECTION
TOP EXIST. WALL EL. 16.5±
VARIES EL. 14.9 TO 17.1
SIDEWALK
DSWL EL. 11.2
SWL EL. 10.3 1978
25'
EL. 8.0
EXISTING GROUND EL. 0.0±
EXISTING BEACH
MHW EL. 4.9
30'
COMPACTED GRANULAR FILL
3.0' STONE BEDDING
2.0' GRAVEL BEDDING
FILTER FABRIC
REACH "I" - LYNN BEACH REVETMENT (NOT JUSTIFIED)
EL. 14.0 (500 YR.)
EXISTING GROUND EL. 9.0±
STEEL SHEET PILES (PZ-27 OR PZ-40)
EXISTING BULKHEAD
EXISTING GROUND EL. -1.0±
BOTTOM TO EL. -40.0 OR -56.0
REACHES "D" AND "F" - TYPICAL STEEL SHEET PILE WALL SECTION
LANDSIDE
LYNN HARBOR
NAHANT ROTARY
LYNN BEACH
1.5'
EXISTING GROUND EL. 9.0±
EL. 14.0 (500 YR.)
h
3' MIN.
DSWL EL. 11.2
EXISTING BULKHEAD (REACH "D")
2h
EXISTING GROUND EL. -1.0± (REACH "D")
REACH "D" - LYNN HARBOR MARINE AREA AND PART OF REACH "H" I-WALL SECTION
2'
EXISTING GROUND EL. 13
EL. 14.0
1'
4'
CONC.
3.5'
REACH F CONCRETE GRAVITY WALL (SPN ONLY)
500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)
LYNN - HARBOR AND BEACH
LOCAL PROTECTION AND REGIONAL PLANS
OPTIONS 1 AND 3
SECTIONS
DECEMBER 1986

PLATE R-8



500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)

LYNN-SAUGUS RIVER

LOCAL PROTECTION PLAN
OPTION 1A
SECTIONS
DECEMBER 1986

development plans will be reviewed in the design stage to determine if there should be any change in the alignment.

Reach "F" - Only tide gates were included in this reach for discharge outlets. The developer of the land plans to raise the ground to EL. 13 ft. NGVD with stone protection dikes along the shorefront in the near future to reduce overtopping.

Reach "G" - No improvements are required along Heritage Park.

Initial Lynn Beach Alignments -

Reach "H" - A wall is shown to protect the Lynn Beach/Nahant Rotary area from Lynn Harbor high tides. The wall connects to high ground at the Lynnway at one end, and to the walls along the MDC Lynn Beach at the east end. A closure for the opening at Nahant Parkway may be required, although the road is fairly high at the point where the wall meets the road.

Reach "I" - An armor stone revetment was formulated to reduce wave overtopping along the Lynn Beach seawall, and reduce the rate of deterioration and repairs to the MDC seawall. The wall appears to require repairs and maintenance similar to Revere Beach seawalls, which are also subject to daily pounding of waves. About every 20 years major repairs are required for concrete walls along Revere Beach. Reach I meets high ground at the north end of Lynn Beach.

Initial Saugus River Alignments -

Reaches "J", "K", and "L" - are generally along the shorefront of the General Electric Company. Combinations of walls and dikes would be used to prevent waves from overtopping the shorefront. There are significant costs associated with this reach due to about thirty discharge pipes requiring gated openings, as well as the walls being needed in confined areas.

Reaches "M" to "R" - generally follow the Saugus riverbank with walls and or dikes. It includes a tide gate at the Strawberry Brook outlet which flows into the little River. Commercial, residential and condominium lands abut the alignments.

The major results of preliminary investigation along the Saugus River for Option 1A (primarily dikes) and Option 1B, (primarily walls) and the described shorefront protection along Lynn harbor and Lynn Beach areas are shown. Option 1B would have cost $1.5 million more to reduce the impact on 4 acres of wetlands.

INITIAL PLANS - 500 YEAR

	Option 1A (Primarily Dikes)	Option 1B (Primarily Walls)
Vegetated Wetland Impacted:	6 Acres	2 Acres
Coastal Mudflats & River Bank/ Bottom Impacted:	23 Acres	17 Acres
Plan Net Benefits: ($1000)	$1,550	$1,400

There was no support for this plan from city officials due to the impacts along the riverbanks and General Electric property. General Electric officials opposed the plan due to the impacts it would have; delaying their operation during construction of the walls and dikes and especially the shutting down of existing discharge pipes during construction of the many tide gates. General Electric officials prefer the Regional Plan which would not have significant impacts on their operations during construction.

Many Technical Group members are strongly opposed to the Local Protection Plans due to the potential impact on the wetlands and disruption along the Saugus River shorefront.

Initial Plan - Revised - The complete lack of support for this plan resulted in only a few changes, including an update of costs, adjusting contingencies for uncertainties in design, adding mitigation costs, completing an environmental assessment, modification to the Lynn Harbor features, and completing the benefit analyses of existing shorefront structures and sea level rise. Contingencies were increased, for example, due to the construction of three new condominium developments along the Saugus River, a future marina development in Reach A, and costs to provide water supply to GE while walls and dikes are constructed. The following additional changes have occurred in the LPP plan.

<u>Revised Lynn Harbor Alignments</u>

Reaches "A" to "D"

. no significant changes in alignments

. costs were updated, and a detailed environmental assessment and shorefront benefit analysis were accomplished. Due to the height of the steel sheet pile wall fronting Gloucester Fish to the inlet, tie backs were needed and permanent easements for the real estate. Additional options were investigated shown with the Selected Plan, including moving the dike inland and replacement of the existing bulkhead in Reaches "A" to "C" with a steel sheet pile wall to reduce the loss of sand flats. The cost however, was significantly higher.

Reach "E" - The alignment was revised for the dike by moving it along the shorefront rather than locating it out in the sand flats at the edge of the property line. Since there are no definite plans by property owners and the value of wetland real estate was lowered, the alignment was changed to follow the shoreline. Moving the dike inland and wall options were also investigated, but discarded due to a higher cost.

Reach "F" - The major change in this reach was to include 280 feet of shoreline owned by the city not included in the developers plans. Therefore walls are required to prevent overtopping. The drainage in Reach "F" includes discharge pipes which drain both the floodplain area and high ground in the city. Reach "F" ties into high ground at Heritage Park, Reach "G" using a sandbag closure across the east bound lane of Lynnway.

Lynn Beach - The Shorefront benefit analysis was completed for reducing damages to the existing Lynn Beach walls based on the history of repairs and replacement of the wall provided by the MDC. As a result, the flood damage reduction benefits to the 25 buildings protected plus the shorefront benefit were insufficient to justify a federal component to the project. In June 1987 the Corps met with the MDC and city of Lynn to review the results of the analysis. Protective measures for Lynn Beach in Reaches "H" and "I" were thus deleted from the plan. The MDC however, has a proposed beach nourishment project for Lynn Beach which would significantly reduce damages to these properties, thus no additional investigations were accomplished.

Saugus River - Reaches "J" to "R" - cost updates on the plan were accomplished as well as completion of an environmental and shorefront benefit assessment.

During removal of two large industrial buildings in the 100 year floodplain at General Electric (GE), the flood damages were reviewed with GE resulting in significant reduction in damages and benefits.

Option 1B, was not investigated further due to the $1 million higher cost of all walls along the Saugus River compared to the lower cost of dikes.

A separate LPP project to protect only GE with walls surrounding their property was also evaluated. The results showed the benefits nearly equaled the costs. Thus the most feasible LPP project for Lynn is as previously described, excluding the Lynn Beach area.

The project first cost includes mitigation for creating 14.0 acres of intertidal clamflats at the I-95 fill and another 2.9 acres (includes an additional 10%) of wetlands.

CITY OF LYNN LPP
BENEFITS, COSTS AND ECONOMIC ANALYSES

Lynn Economic Summary ($1000)

PLAN:	100 yr	500 yr	SPN
First Cost	$30,430	$32,330	$34,720
Average Annual Benefits	2,901	3,282	3,499
Average Annual Cost	2,941	3,125	3,356
Average Annual Net Benefit	-40	157	143
Benefit-to-Cost Ratio	0.9	1.05	1.04

Environmental Impacts - The following resource acreage is impacted by construction of the shorefront structures:

Type of Land	Impacted Acreage Option 1A
Developed	2.0
Open Space, Woodlands	2.0
Vegetated Wetlands Lost	2.6 (along the Saugus River)
Intertidal Habitat Lost	14.8 (River and Harbor)
Total Acres	21.4

Lynn LPP Concerns - Due to the impact of construction activities along General Electrics' shore and interruption in business, the plan would have problems in being implemented. The interruptions might be minimized by coordinating scheduling of work, or making up delays on overtime. It is unknown whether a non federal funding source could be obtained. The city is committed to making the shorefront accessible to the public which would help in obtaining state funds.

The technical feasibility of this plan functioning properly during a storm is very dependent on the closure of thirty-five (35) sluice gates and eight gates along walls and dikes needed for commercial and recreation access to the waterfront.

OPTION #1 - EAST SAUGUS LPP

Initial Plans - The East Saugus local protection area shown on Plate R10 is divided into reaches of shorefront from A to F. Preliminary plans formulated to reduce overtopping for the 500 year storm included both walls and dikes along the shorefront. In addition to the alignments shown, other alignments were also evaluated including walls all along the Saugus River from the GE pipe line opposite RESCO to Lincoln St. Bridge. The high cost of the walls to protect areas along Rt. 107 and Ballard Street to Eastern Avenue in comparison to the damages prevented were not economically justified.

The preliminary plans coordinated with the Committees and Technical Groups included both Option 1A (primarily dikes) and Option 1B (primarily walls). Option 1A plans and profiles are shown on Plates R10 and R11. The summary of these plans were:

	Option 1A	Option 1B
Project Net Benefits	$160,000	(-$685,000)
Vegetated Wetlands Impacted	13 Acres	5 Acres

Option 1A was strongly opposed by most Technical Group members due to its impact on wetlands. The Saugus Citizen Steering Committee opposed Option 1 since the cost of both plans were prohibitive to Saugus and especially because height of walls and dikes around the neighborhoods would make the plan objectionable.

Revised Plan - Option 1A and 1B were reviewed to reduce the impact on wetlands when revised real estate values showed that the impact on real estate of underdeveloped lots in the marsh was considerably less than originally estimated. Walls were then located near the edge of developed lots for Option 1B, rather than detour around these underdeveloped lots through the marsh. Also the costs for the plan were updated and contingencies adjusted for uncertainties in design.

Also, Saugus in establishing a position on the removal of the I-95 land fill made it very clear that the material can not be used or lowered near the residential area, ("Reach B") since it provided a buffer against the noise, sight and other problems from Route 107 and RESCO. There is a possibility the I-95 parcels in Reach B could be turned back to the original land owners. If this occurred and the sand removed costs for this plan would significantly increase.

The cost of a dike along Reach B was therefore deleted from both Options. Reach B therefore includes the existing I-95 fill. Concrete "I" walls in Reaches "A", and "C" to "F" tying into the I-95 fill were used for the Option 1 plan. Benefits and costs were also updated or completed. In the end Option 1B would cost about $700,000 more than Option 1A. Option 1A therefore is used to represent the LPP Option 1.

Plan Description - The East Saugus LPP, Option 1A, would protect about 550 residential public, and commercial buildings. Walls bordering marshland, the Pines River, open areas and roadways are included for the protection (Plate R-10).

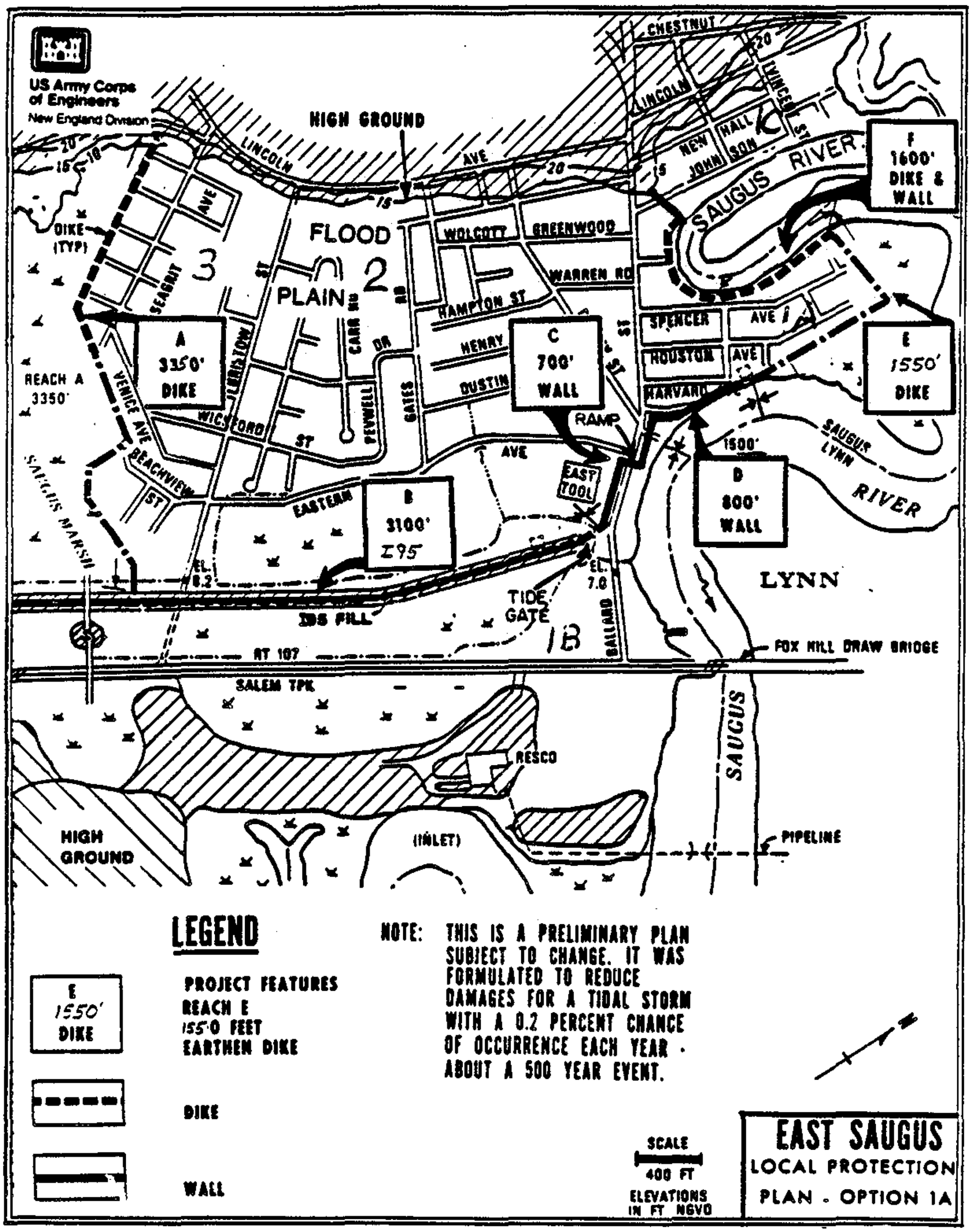
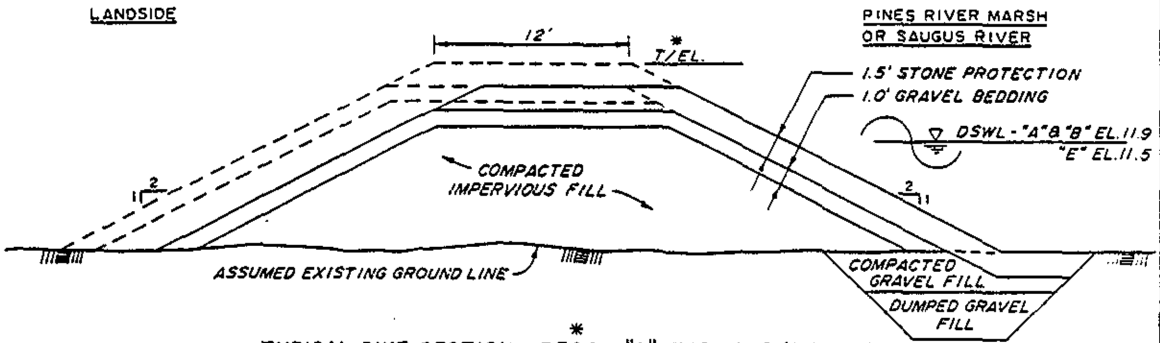

US Army Corps of Engineers
New England Division
HIGH GROUND
LINCOLN AVE
CHESTNUT
FLOOD PLAIN 2
3
SAUGUS RIVER
F 1600' DIKE & WALL
WOLCOTT
GREENWOOD
WARREN RD
HAMPTON ST
HENRY
DUSTIN
SPENCER
HOUSTON
HARVARD
DIKE (TYP)
SEAGRIT
A 3350' DIKE
REACH A 3350'
C 700' WALL
E 1550' DIKE
RAMP
WICKFORD ST
VENICE AVE
BEACHVIEW ST
EASTERN AVE
B 3100' I95
EAST TOOL
1500'
D 800' WALL
SAUGUS LYNN
RIVER
LYNN
SAUGUS MARSH
EL. 8.2
EL. 7.0
TIDE GATE
I95 FILL
BALLARD
RT 107
FOX HILL DRAW BRIDGE
SALEM TPK
RESCO
SAUGUS
HIGH GROUND
(INLET)
PIPELINE
LEGEND
E 1550' DIKE
PROJECT FEATURES
REACH E
1550 FEET
EARTHEN DIKE
DIKE
WALL
NOTE: THIS IS A PRELIMINARY PLAN SUBJECT TO CHANGE. IT WAS FORMULATED TO REDUCE DAMAGES FOR A TIDAL STORM WITH A 0.2 PERCENT CHANCE OF OCCURRENCE EACH YEAR - ABOUT A 500 YEAR EVENT.
SCALE
400 FT
ELEVATIONS IN FT NGVD
EAST SAUGUS
LOCAL PROTECTION
PLAN - OPTION 1A

PLATE R-10

NOTES:

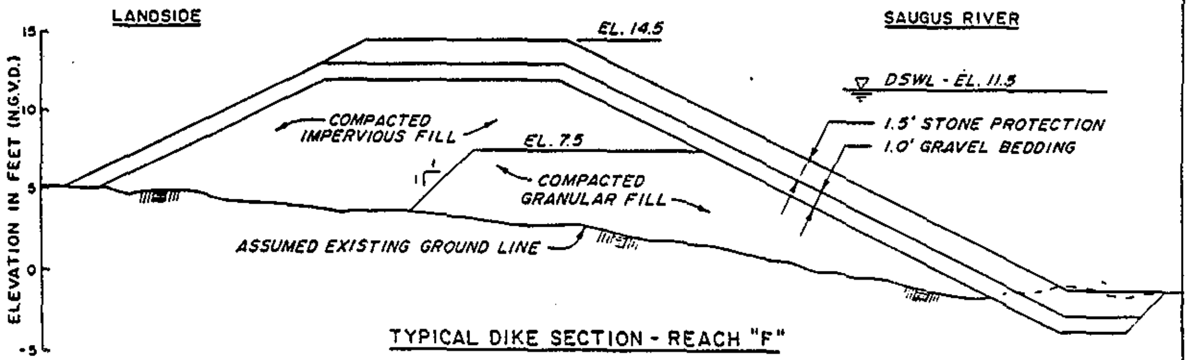
1. DIKES SUBJECTED TO OVERTOPPING.
2. TOP ELEVATION INCREASE 1.5' IN MARSH AREA (DASHED LINE).
3. DUMPED GRAVEL FILL ONLY REQUIRED IN MARSH AREAS.



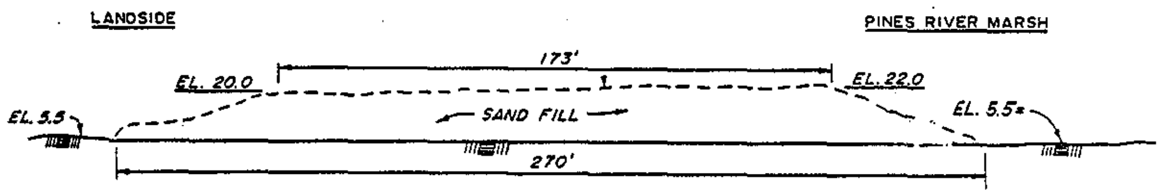
*

TYPICAL DIKE SECTION - REACH "A" T/EL. 16.5 (MARSH)

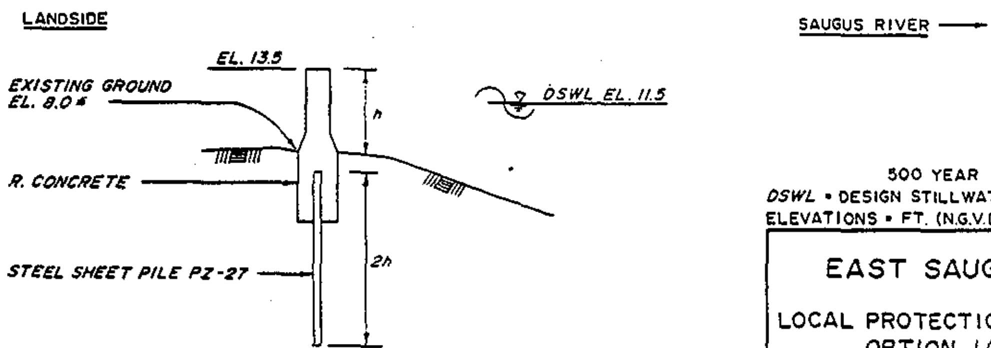
REACH "E" T/EL. 16.0 (MARSH)



TYPICAL DIKE SECTION - REACH "F"



I-95 FILL CROSS SECTION - REACH "B"



TYPICAL I-WALL - REACHES "C","D", PART "B", "F"

500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)

EAST SAUGUS

LOCAL PROTECTION PLAN
OPTION 1A
SECTIONS

PLATE R-11

Reach "A" - includes a dike with stone facing which borders along the edge of properties.

Reach "B" - includes the state's I-95 embankment and right-of-way. A tide gate is included at the north end of the embankment for the existing drainage ditch.

An alternate, but not justified, alignment includes Reach "A" tying into high ground opposite Rt. 107. A wall along the river about 1,000 feet downstream of Rt. 107 would then join the high ground to Reach "D". This alignment would have protected businesses along Ballard Street in Zone 1B but was not economically justified.

Another alignment considered walls of dikes along the edge of Eastern Ave. Construction, however, would adversely impact developable land along the road resulting in high real estate costs, which were not economically justified.

Reach "C" - includes an I-wall along Ballard Street and the bank of the Pines river. Gated openings would be provided for the public boat ramp and access required by others to the river. A ramp on Ballard Street is included.

Reach "D" - includes an I-wall along the bank of the Pines River. Gated openings would be provided for the public boat ramp and access required by others to the river.

Reach "E" and "F" - includes a stone faced dike along the riverbank and a wall inland to high ground.

<u>Mitigation</u> - The I-95 fill would be removed to mitigate losses, clamflats would be created for 1.5 acres, and 8.1 acres (includes 10%) of wetlands would be created. Costs are included in the project first cost.

An alternate alignment included extending walls and dikes along the edge of the river to high ground in the vicinity of the Lincoln St. Bridge to protect Zone 1C. This extension was not economically justified.

EAST SAUGUS ECONOMIC SUMMARY ($1000)

	100 yr	500 yr	SPN
First Cost	$10,170	$10,890	$11,610
Average Annual Benefit	1,123	$ 1,209	$ 1,245
Average Annual Cost	1,006	1,073	1,139
Average Annual Net Benefits	117	136	106
Benefit-to-Cost Ratio	1.12	1.13	1.09

Environmental Impacts - The following types of land were impacted by the plan:

		East Saugus Impacted Acreage
Developed		1.0
Open Space		-
Vegetated Wetlands Lost		7.4
Intertidal Habitat Lost		1.5
	Total	9.9

A significant adverse impact is the five to seven foot height of walls and dikes along the residential areas for the 500 year plan. A 100 year plan to provide protection against a recurring 1978 storm would only lower walls and dikes about one foot.

Concerns - The Federal cost of LPP plans would be 65%. The non-federal cost is 35% less a credit for the value of real estate. The town of Saugus would have considerable problems meeting this requirement.

The Citizen Steering Committee voiced strong opposition to the plan and it is not supported by the town. The problem of financing the non-federal cost and height of walls were cited as major reasons for objection to it. In addition there was a very strong preference for option 3, the Regional Plan.

The technical feasibility of this plan functioning properly during a storm is dependent on closing of 14 - swing gates along the dikes and walls for commercial access, as well as closure of two large sluice gates and several smaller ones.

TOWN LINE BROOK LOCAL PROTECTION PLAN

Plan Description - The Town Line Brook LPP includes protection for about 1000 homes and businesses in the Town Line and Linden Brook watersheds of Revere and Malden. The MDC currently has plans to construct shoreline improvements, a pumping station and interior drainage improvements. MDC officials expect the shoreline would be raised to provide 100 year level of protection from high tides, if the Regional Plan is not built.

Only shorefront improvements related to high tides are addressed in this study. Costs of these improvements could be eliminated under the Regional Plan, Option 3. Depending on the timing of MDC and Corps projects, these features may become an alternative to the Regional Plan. Plates R-12 and R-13 include the Option 1A plan and sections. The cost and environmental savings for this LPP would provide a comparable estimate to Option 3. The following features are either needed by the LPP for storm tides or could be eliminated by Option 3:

Reach "A" - The road surface of Copeland Circle is high enough to prevent overtopping. Only a tide gate on the existing culvert would likely be needed.

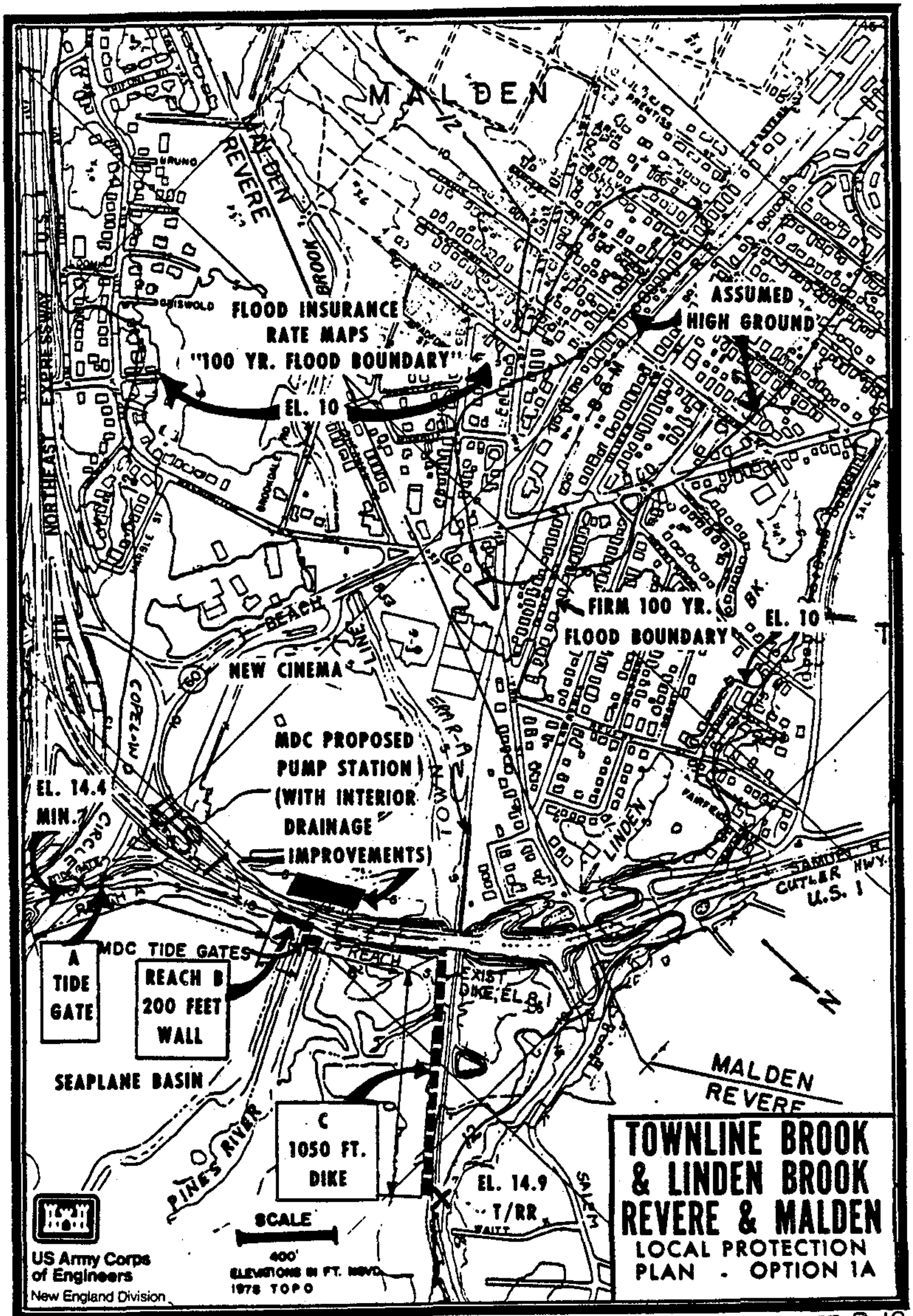
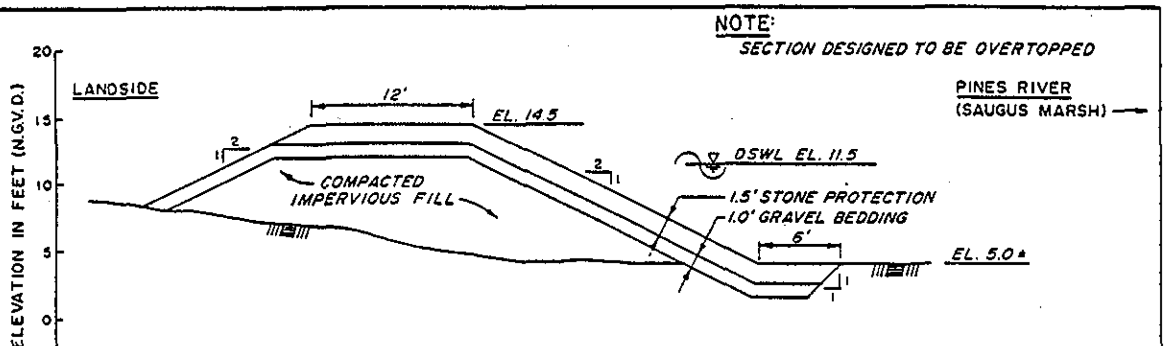
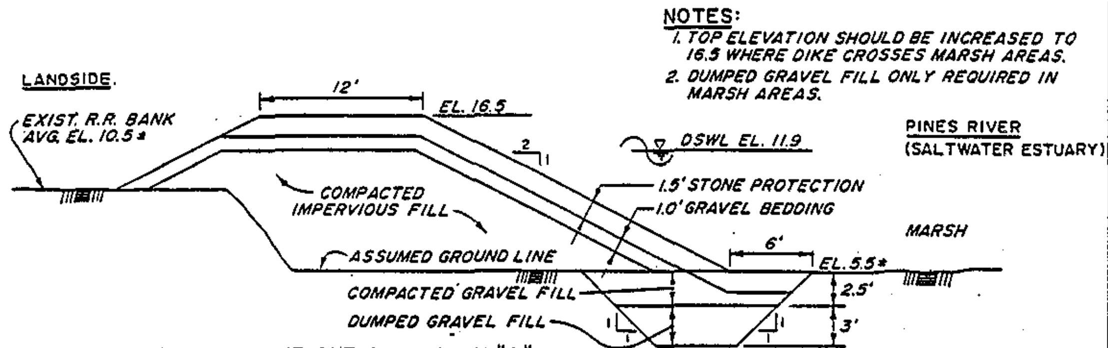

MALDEN
REVERE
MALDEN
BROOK
FLOOD INSURANCE
RATE MAPS
"100 YR. FLOOD BOUNDARY"
EL. 10
ASSUMED
HIGH GROUND
NORTHEAST EXPRESSWAY
FIRM 100 YR.
FLOOD BOUNDARY
EL. 10
BEACH
NEW CINEMA
LINE
MDC PROPOSED
PUMP STATION
(WITH INTERIOR
DRAINAGE
IMPROVEMENTS)
EL. 14.4
MIN.
CIRCLE
TOWNLINE
LINDEN
SAMUEL R. CUTLER HWY.
U.S. 1
MDC TIDE GATES
A
TIDE
GATE
REACH B
200 FEET
WALL
EXIST
DIKE EL 8.1
SEAPLANE BASIN
MALDEN
REVERE
C
1050 FT.
DIKE
PINES RIVER
EL. 14.9
T/RR
SALEM
SCALE
400'
ELEVATIONS IN FT. NGVD
1978 TOPO
US Army Corps
of Engineers
New England Division
TOWNLINE BROOK
& LINDEN BROOK
REVERE & MALDEN
LOCAL PROTECTION
PLAN - OPTION 1A

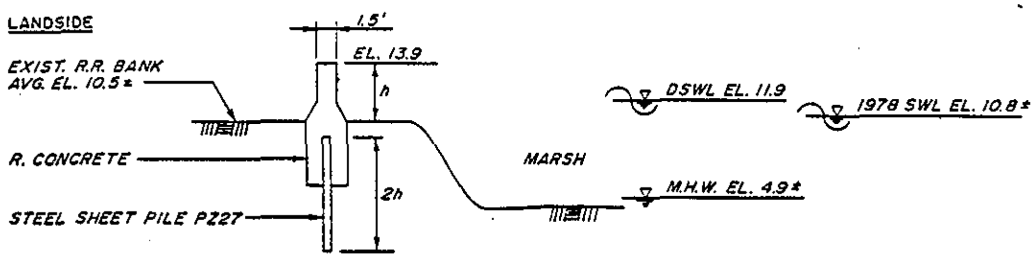
PLATE R-12



DIKE SECTION - REACH "A"
NORTHGATE AREA, REVERE



TYPICAL DIKE OPTION - REACH "C"
(DIKE OPTION) SECTION DESIGNED TO BE OVERTOPPED
TOWN LINE BROOK



TYPICAL I-WALL - REACH "C" WALL OPTION
TOWN LINE BROOK

500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)

CONCRETE GRAVITY WALL - REACH "B"
TOWN LINE BROOK

TOWN LINE BROOK
AND
NORTHGATE AREA
LOCAL PROTECTION PLANS
OPTION I
SECTIONS
DECEMBER 1986

Reach "B" - Route U.S. 1 drops in elevation in the vicinity of the MDC tide gates. A gravity wall for a 500 year design along the riverside of the guardrail would be required to reduce overtopping. The need for frequently replacing the six large MDC tide gates would be reduced. The 100 year level of protection requires the tide gates be maintained; however, the gravity wall would not likely be constructed.

Reach "C" - A dike for Option 1A would run parallel along the edge of the existing MDC dike and railroad embankment to prevent tides from overtopping into the area. A gated access is included in the vicinity of this existing dike and roadway for access to the tide gates. Option 1B used a wall along the top of the railroad embankment which impacted the wetlands.

Mitigation - Project First Cost includes the mitigation of 1.1 acres of vegetated wetlands by creating 1.2 acres (includes 10%) of vegetated wetlands by removal of the I-95 fill.

Benefits, Costs and Economic Analyses -

For purposes of comparing benefits and costs to the Regional Plan, benefits are made equal to the annual project cost.

TOWN LINE BROOK ECONOMIC SUMMARY

	100 YEAR
First Cost	$800,000
Average Annual Benefits	$ 78,000
Average Annual Costs	$ 78,000
Average Annual Net Benefits	0
Benefits-to-Cost Ratio	1

Environmental Impacts - the following resource acreage would be impacted by construction:

Type of Land	IMPACT ACREAGE Option 1A (acres)
Open Space	1.0
Vegetated Wetlands Lost	1.1
Total Acreage	2.1

The wall in Reach C would impact about an acre of open space along the railroad and dike embankments. When replaced by walls, only a small impact on open space results. (Rounding to the nearest acre fails to show the change in open space impacted).

Other Impacts - There would be some construction impact on the adjacent quarry operations to the west of the railroad embankment.

Public Views - Malden officials have expressed a preference for the Regional Plan. MDC officials prefer the Regional Plan.

Implementation - Implementation of this plan is currently planned as part of the MDC's project.

OPTION 1 - NORTHGATE AREA LPP

Plan Description - Several alignments for dikes and walls were investigated to protect the residents and businesses southeast of the Northgate Shopping Center bordering the marsh. Plates R-13 and R-14 show typical sections and alignments considered.

BENEFITS, COSTS AND ECONOMIC ANALYSES

		Option 1A		
	Reach A only	Reach A & B		
		100	500	SPN
Project First Cost ($1000):	$ 662	$2260	$2516	$2790
Benefits ($1000):	$ 31	38	45	47
Average Annual Project Cost ($1000)	$ 65	$ 214	$ 237	$ 256
Net Benefits ($1000)	$ -34	$- 176	$-192	$-209
Benefit-to-Cost Ratio:	0.5 to 1.0	0.1	0.1	0.1

Since a plan is not justified no additional plans or impacts were investigated.

Public Views - Residents are very interested in flood protection.

OPTION 1 SUMMARY

Local Protection Plans were investigated for five of the eight geographic areas and four demonstrated potential economic feasibility. Each plan is summarized in the Main Report with the level of protection which produced the highest net economic benefits. The following summarizes the openings with required closures to assure flooding does not enter through the line of protection.

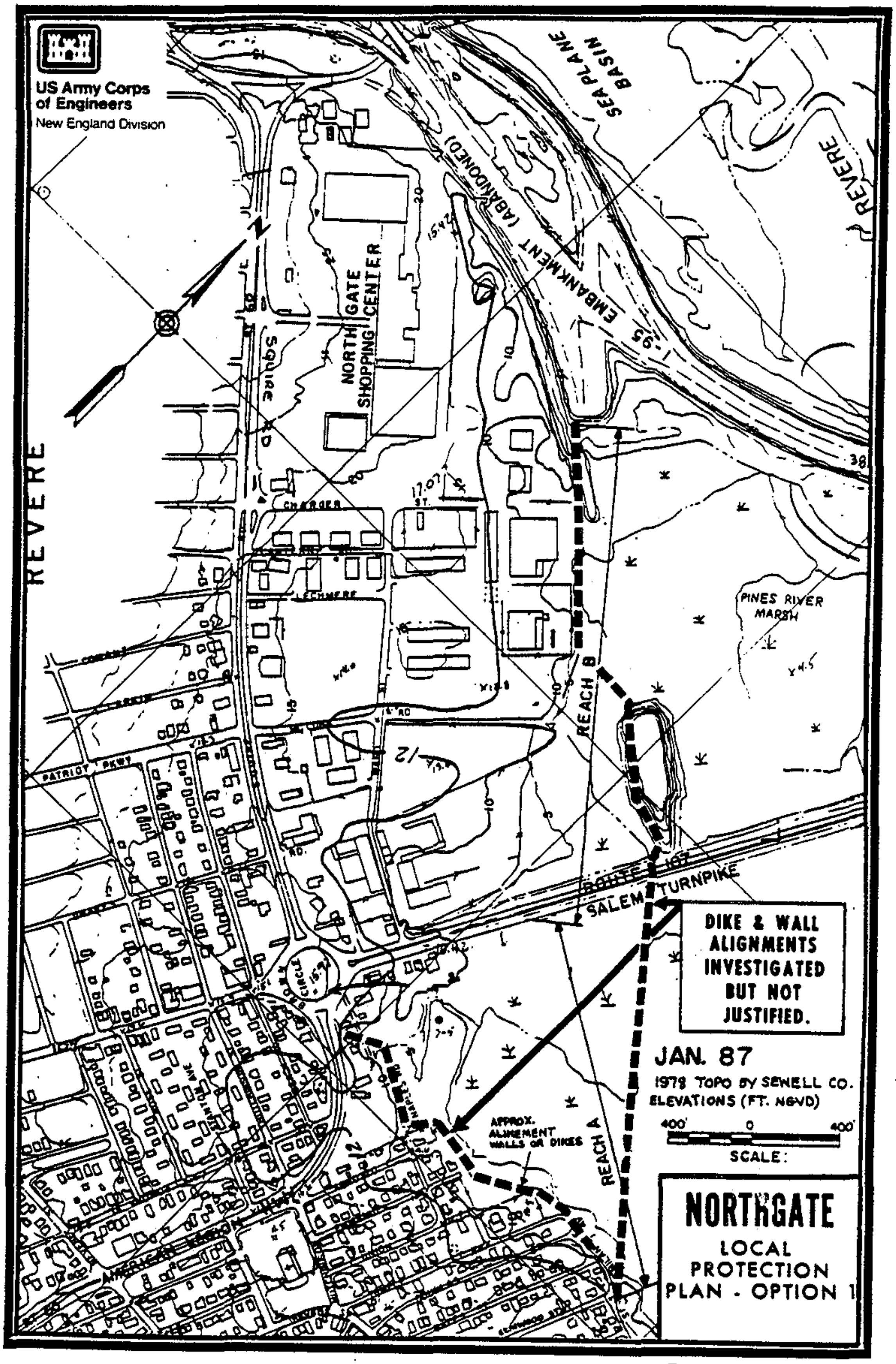

US Army Corps of Engineers
New England Division
REVERE
NORTHGATE SHOPPING CENTER
EMBANKMENT (ABANDONED)
SEA PLANE BASIN
REVERE
I-95
PINES RIVER MARSH
REACH B
REACH A
ROUTE 107
SALEM TURNPIKE
PATRIOT PKWY
LECHMERE
CIRCLE
AMERICAN LEGION HWY
DIKE & WALL ALIGNMENTS INVESTIGATED BUT NOT JUSTIFIED.
APPROX. ALINEMENT WALLS OR DIKES
JAN. 87
1978 TOPO BY SEWELL CO.
ELEVATIONS (FT. NGVD)
400' 0 400'
SCALE:
NORTHGATE
LOCAL PROTECTION PLAN - OPTION 1

PLATE R-14

OPENINGS & CLOSURES

Saugus	18	NEW
Lynn	43	NEW
RBB	10±	NEW
TLB	7	NEW
	78 gates and closures	

OPTION 2 - NONSTRUCTURAL PLANS

Description - Nonstructural plans include, for example, floodproofing and floodwarning measures which reduce flood damages to individual buildings. They include Structure Raising, Utility Cells, Utility Rooms, and Closures for doors, windows or other openings. The measures would reduce the vulnerability to flooding by alerting residents to move property above flood levels and evacuate the area. Floodproofing may be feasible for a limited number of buildings.

The results in Revere, Lynn and East Saugus were that only a very limited number of buildings demonstrated sufficient benefits to equal or exceed the costs for flood proofing. Out of 2100 homes surveyed in the 100 year (i.e., 1978) floodplain, only 171 were potential candidates for home raising or 8%. Out of 585 commercial and public buildings 68 or 12% were estimated to be candidates for Closures. In the 100 year floodplain a total of about 240 buildings could be floodproofed or raised out of 2685 investigated or 9 percent. In the SPN floodplain this equals a total of 7 percent. (See Table 8). Addendum 6 includes additional information on nonstructural methods.

In addition to home raising and flood proofing, the nonstructural plan also includes:

- assurance from the state and communities that existing floodplain management laws would be publicized each year and strictly enforced. This would reduce damages to future construction.

Alternatives - The feasibility of Utility Cells and Utility Rooms was also investigated, however these measures were not as cost effective as raising homes which not only protects utilities but also prevents flooding of first floors for comparable floods. As discussed under Management Measures the following measures, alone, would not significantly reduce flood damages in the study area: Flood Insurance, Floodplain Regulations, and Flood Warning and Evacuation. They are however required in combination with all plans. Acquisition of floodplain land is discussed in a following section.

BENEFITS, COSTS AND ECONOMIC ANALYSES

Project First Cost	$ 7.4 million
Flood Damage Reduction Benefits ($1000)	$ 1370
Average Annual Project Costs ($1000):	$ 670
Net Benefits ($1000):	$ 700
Benefit-to-Cost Ratio:	2.0 to 1.0

TABLE 8

NONSTRUCTURAL SUMMARY - OPTION 2

LOCATION	BUILDINGS IN 100 YR. FLOODPLAIN FEASIBLE %	FEASIBLE Number	TOTAL Number	FOR BUILDINGS ESTIMATED WITH FEASIBLE MEASURES: FIRST COST ($1000)	AVG. ANN. COST ($1000)	AVG. ANN BENEFITS ($1000)	BENEFIT TO-COST Ratio	NET BENEFITS ($1000)
LYNN								
Residents	8	28	370	$ 900	$ 80	$ 230	2.9	$ 150
Non Res.	12	50	420	950	80	155	1.9	75
TOTAL	10	78	790	$1850	$ 160	385	2.4	$ 225
E.SAUGUS*								
Residents	13	69	525	$2424	$ 220	$ 465	2.1	$ 245
Non Res.	17	4	25	80	8	12	1.7	4
TOTAL	13	73	550	$2504	$ 228	$ 477	2.1	$ 249
REVERE*								
Residents	6	74	1205	$2830	$ 257	$ 471	1.8	$ 214
Non Res.	10	14	14	250	22	$ 40	1.8	18
TOTAL	7	88	1349	$3080	$ 279	$ 511	1.8	$ 232
TOTALS								
Residents	8	171	2100					
Non Res.	12	68	585					
Grand Total	9	239	2685	$7434	$ 667	$1373	2.0	$ 706
Say:	9	240	2685	$7400	$ 670	$1370	2.0	$ 700

BUILDINGS IN SPN FLOODPLAIN FOR AREAS INVESTIGATED

	FEASIBLE %	FEASIBLE Number	TOTAL
LYNN	6%	78	1240
E. SAUGUS	12%	73	600
REVERE	5%	88	1850
TOTAL	7%	239	3650

* Revere includes Revere Beach Backshore, Point of Pines and North Gate, but not Town Line BK.

* East Saugus does not include the Upper Saugus River & Shute BK.

Malden is also not included, due to current design underway for the MDC Town Line & Linden Brooks project.

Environmental Impacts - Impacts would result to individual property owners as their buildings, yards or properties are modified for floodproofing.

Public Views - Local communities have not indicated an interest in this option. The State's Executive Office of Environmental Affairs has indicated an interest to investigate the option, since it would have negligible impacts on the environment.

Flood Proofing Analysis - The analysis for flood proofing homes and businesses was accomplished by performing detailed damage surveys of the Revere Beach Backshore area and developing both the benefits and costs for about 1200 buildings in the SPN floodplain. The results of raising buildings, flood proofing them, using utility cells or rooms was completed prior to the start of the Regional Study. The results in Revere were reported to the Steering Committees. Only 8 percent of the buildings in the 100 year floodplain or 5 percent in the SPN floodplain demonstrated feasibility for flood proofing at that time. Raising homes proved more cost effective than utility cells or utility rooms for homes. For commercial buildings flood proofing foundations and closures for openings was the most effective. Revere Beach Backshore was reported as being the most feasible location for raising homes or flood proofing due to its higher depths and frequency of flooding compared to the other locations in the study area.

The Citizen Steering Committee's in the communities did not support or were even interested in the nonstructural approach since it would not provide a high degree of flood protection to their communities. As a result no additional nonstructural investigations were planned. The analysis used to develop the nonstructural benefits was very labor intensive.

During coordination with the Technical Group, several state agencies requested that the nonstructural analysis be completed for the remaining areas. The effort required to modify the computer program and develop a data base for a similar analysis as Revere Backshore's would have been very labor intensive and estimated to cost in excess of $20,000. Funds were not available, nor was the expenditure warranted in light of the complete lack of support for the analysis by the communities, so an alternate method was used. The Point of Pines' analysis had previously been accomplished during its investigations. The remaining areas of Lynn, East Saugus and North Gate were accomplished under an alternate method.

An analysis of the cost of raising homes was available in a FEMA 1986 publication, "Floodproofing Non-Residential Structures." The analysis for raising buildings, applicable to residential structures as well, required only the type of building, square footage of the first floor and height to be raised. The topographic maps (with first floor survey data) were used to obtain the elevation of first floors and square footage. The height to be raised was developed from the flood elevations developed for each area and first floors. The type of building and address was available from damage surveys. Topo maps with addresses on each building had also been prepared during the damage surveys. Only those buildings whose first floors would have one foot or more water above the first floor for the 100 year floodplain were analyzed since raising a structure less than one foot was assumed not practical or cost effective in the vast majority of cases. In some cases where there are finished basements and with living quarters, raising may prove cost effective with less than one foot of water above the first floor. Due to the limited number of these situations found in Revere, the above criteria for initial screening of buildings was used to complete the planning analysis for the study area.

The analysis was first run for the Revere Beach Backshore area (Table 9) comparing annual benefits to the annual cost of raising. The results were that 62 homes were candidates for raising, slightly higher than the 46 homes initially estimated. A review of the Revere results showed that for a particular type of home their benefits were generally at least $4000 to $5000. With an average depth of flood water of 2 feet above the first floor.

A benefit to reasonably represent each type of home was therefore selected from the Revere results. The "selected annual benefit" was then used for the feasibility analysis in other area. The resulting "total benefit" of feasible buildings in each area was increased to more accurately reflect total benefits since the "selected annual benefit" was lower than the Revere average. The cost of raising buildings in all three communities were computed on a building by building basis.

The results of raising homes in the Revere, Lynn and East Saugus areas are shown on Tables 9, 10 and 11. To determine the estimated number of commercial buildings in Lynn and Saugus which would likely be candidates for flood proofing, the results of the building by building detailed analysis in Revere was used. The Lynn and Saugus commercial buildings are an estimate based on a similar percentage of feasible buildings found in Revere.

Since the average depth of flood water, or average height buildings would be raised, in Saugus and Lynn was only 1.67 feet compared to Revere's 4.2 feet, their benefits are probably over estimated as well as the number of potentially feasible raised buildings, nevertheless, the results of the nonstructural analysis provides an indication of the feasibility of nonstructural flood proofing in the study area.

<u>Public Acquisition of Flood Plain Land</u> - Public control over the flood plain may be obtained by purchasing the title or some lesser rights such as development or public access rights. Acquisition of the title is better suited for undeveloped or sparsely developed land in the flood plain. It is a very desirable means, however, of protecting and/or providing for environmental and wildlife protection, public open space and recreation or other purposes.

The acquisition cost of residential properties, in the 100 year floodplains of Revere Beach Backshore (698 buildings), Point of Pines (357), Northgate (50), Lynn (370) and East Saugus (525) are included in this analysis. The acquisition cost for these 2000 residential properties would be about $300,000,000 bases on an average fair market value in the area of $150,000 per home.

Since commercial and industrial (C/I) land use in the 100 year floodplain is 450 acres with an average fair market value of about $1,300,000 per acre, the additional acquisition cost for C/I property would likely exceed $600,000,000.

The total estimated acquisition cost of residential, commercial and industrial properties in the 100 year floodplain would be $900 million, or about $1 billion. Other alternatives being considered are far less expensive while providing a comparable level of protection.

Also see Addendum 5 for additional information on Nonstructural Methods.

TABLE 9

FLOOD PROOFING PLAN

HOUSE RAISING
++++++++++++++++++++

1/3

PROJECT: **REVERE BEACH BACKSHORE AREA**

Current 20 City ENR Cost Index:	4476 as of May 88
Current GNP Index:	119.3 as of May 88
Enter % Contingencies:	25
Enter % E&D and S&A:	25

Interest Duringa Construction Based on 8 5/8% for a Period of 4 Months. (1.042)
Capitol Recovery Based on a 50 yr. Period. (.08765)

TABLE 1: STRUCTURE TYPES

Wood Frame Single Story, Unfinished Basement	11
Wood Frame Single Story, Finished Basement	12
Brick or Masonry Single Story, Unfinished Basement	21
Brick or Masonry Single Story, Finished Basement	22
Single Story Slab-on-Grade	30
Wood Frame Two Story, Unfinished Basement	31
Wood Frame Two Story, Finished Basement	32

100 YR. FLOOD PROTECTION

ADDRESS	STRUCTURE TYPE (11-32)	FLOOR AREA (sf.)	FIRST FLOOR ELEV.	HT. TO RAISE BLDG.	FIRST COST	AVERAGE ANNUAL COST	AVERAGE ANNUAL BENEFIT	NET BENEFIT	BCR
55 Eliot Rd.	30	1,500	4.2	2.9	$56,655	$5,174	$4,786	($389)	0.92
50 Avalon St.	11	1,800	4.2	2.9	$41,572	$3,797	$4,774	$977	1.26
2 Porter Ave.	21	1,900	4.5	2.6	$56,555	$5,165	$6,197	$1,032	1.20
4 Porter Ave.	11	1,200	4.6	2.5	$27,715	$2,531	$5,428	$2,897	2.14
54 Eliot Rd.	30	750	4.2	2.9	$28,328	$2,587	$7,517	$4,930	2.91
68 Neponset St.	30	1,400	4.1	7.3	$53,929	$4,925	$6,220	$1,295	1.26
73 Dunn Rd.	30	900	5.2	6.2	$34,278	$3,131	$4,258	$1,127	1.36
31 Neponset St.	30	900	4.5	6.9	$34,278	$3,131	$5,360	$2,229	1.71
75 Sagamore St.	30	1,500	5	6.4	$57,131	$5,218	$5,842	$624	1.12
114 Sagamore ST.	30	1,300	5.4	6	$49,513	$4,522	$5,360	$838	1.19
64 Shawmut ST.	30	1,100	5.4	6	$41,896	$3,826	$5,360	$1,533	1.40
63 Shawmut St.	30	900	5	6.4	$34,278	$3,131	$5,520	$2,390	1.76
112 Sagamore St.	31	1,300	7.8	3.6	$49,101	$4,484	$4,464	($20)	1.00
42 Agawam St.	32	1,100	4.8	6.6	$41,896	$3,826	$8,550	$4,724	2.23
8 Neponset St.	30	800	5.2	6.2	$30,470	$2,783	$5,532	$2,749	1.99
82 Sagamore St.	30	1,300	4.9	6.5	$49,513	$4,522	$8,539	$4,017	1.89
20 1/2 Dunn Rd.	32	900	7.2	4.2	$33,993	$3,105	$4,935	$1,830	1.59
19 Neponset St.	31	1,800	5.1	6.3	$68,557	$6,261	$6,932	$671	1.11
70 Neponset St.	31	2,000	4.6	6.8	$76,174	$6,957	$7,322	$365	1.05

TABLE 9: REVERE (CONT)

37 Shawmut St.	31	1,200	3.2	8.2	$46,225	$4,222	$19,051	$14,830	4.51
38 Shawmut St.	31	1,000	4.2	7.2	$38,521	$3,518	$13,497	$9,978	3.84
49 Shawmut St.	31	600	5.6	5.8	$22,852	$2,087	$6,243	$4,156	2.99
62 Shawmut St.	31	700	4.7	6.7	$26,661	$2,435	$8,917	$6,482	3.66
46 Arcadia St.	12	600	4.9	3.4	$13,857	$1,266	$6,863	$5,597	5.42
21 Loring St.	12	900	3.9	4.4	$20,786	$1,898	$5,991	$4,092	3.16
34 Arcadia St.	32	800	6.8	1.5	$30,216	$2,760	$4,556	$1,797	1.65
22 Beverly St.	32	1,000	7.5	1	$37,770	$3,450	$4,648	$1,198	1.35
36 Ellerton St.	32	800	5.5	2.8	$30,216	$2,760	$5,497	$2,738	1.99
52 Ellerton St.	32	900	5.8	2.5	$33,993	$3,105	$5,027	$1,922	1.62
22 Lawrence Rd.	32	800	5.4	2.9	$30,216	$2,760	$6,737	$3,977	2.44
85 Bay Rd.	30	1,700	4.1	4.2	$64,209	$5,864	$6,622	$758	1.13
14 Bay Rd.	31	1,100	4.9	3.4	$41,547	$3,795	$4,625	$831	1.22
38 Bay Rd.	31	1,000	4.4	3.9	$37,770	$3,450	$7,942	$4,492	2.30
59 Ellerton St.	31	1,200	4	4.3	$45,324	$4,140	$9,652	$5.512	2.33
19 Loring St.	31	1,000	5.8	2.5	$37,770	$3,450	$4,671	$1,221	1.35
36 Sears St.	31	900	5.3	3	$33,993	$3,105	$9,445	$6.341	3.04
61 Arcadia St.	32	1,200	4.8	3.5	$45,324	$4,140	$8,080	$3,940	1.95
71 Arcadia St.	32	2,400	5.6	2.7	$90,649	$8,279	$7,976	($303)	0.96
27 Argyle St.	32	1,300	5.3	3	$49,101	$4,484	$10,891	$6,407	2.43
32 Ellerton St.	32	1,200	4.2	4.1	$45,324	$4,140	$9,790	$5,650	2.36
14 York St.	31	1,800	6.4	1.9	$67,986	$6,209	$5,256	($953)	0.85
28 Sears St.	30	2,100	4.3	4	$79,318	$7,244	$10,650	$3,406	1.47
450 Revere Beach Blvd.	11	1,200	4.7	3	$27,715	$2,531	$11,901	$9,370	4.70
57 Oak Island St.	32	1,500	7.3	0.4	$100,000	$9,133	$10,409	$1,276	1.14
532R Revere Bch. Blvd.	30	600	7.6	1.9	$22,662	$2,070	$9,044	$6,974	4.37
					$100,000	$9,133			
45 Eliot Rd.	30	900	8.4	0	$100,000	$9,133	$4,086	($5,047)	0.45
53 Eliot Rd.	30	1,100	8.6	0	$100,000	$9,133	$3,317	($5,816)	0.36
15 Standish Rd.	30	900	8.9	0	$100,000	$9,133	$3,615	($5,518)	0.40
54 Agawam St.	12	700	4.6	6.8	$16,389	$1,497	$4,017	$2,520	2.68
16 Dunn Rd.	12	600	5.1	6.3	$14,048	$1.283	$3,558	$2.275	2.77
28 Shawmut St.	32	800	6	5.4	$30,470	$2,783	$3,581	$798	1.29
68R Neponset St.	30	300	6.2	5.2	$11,426	$1,044	$3,477	$2,434	3.33
115 Sagamore St.	30	1,000	5.6	5.8	$38,087	$3,479	$3,477	($1)	1.00
47 Shawmut St.	30	800	4.7	6.7	$30,470	$2,783	$3,271	$488	1.18
29 Shawmut St.	30	1,500	6.7	4.7	$56,655	$5,174	$3,409	($1,766)	0.66
48 Shawmut St.	30	800	7.8	3.6	$30,216	$2,760	$3,868	$1,108	1.40
95R Sagamore St.	32	900	8.2	3.2	$33,993	$3,105	$3,604	$499	1.16
97R Sagamore St.	32	600	8.6	2.8	$22,662	$2,070	$3,604	$1,534	1.74
52 Shawmut St.	32	800	8.5	2.9	$30,216	$2,760	$3,340	$580	1.21
1 Agawam St.	30	1,600	4.6	6.8	$60,939	$5,566	$3,282	($2,283)	0.59
77 Dunn St.	30	800	8.8	2.6	$30,216	$2,760	$3,546	$787	1.29
55 Shawmut St.	30	2,100	6.8	4.6	$79,318	$7,244	$3,741	($3,503)	0.52
7 Neponset St.	32	900	7.2	4.2	$33,993	$3,105	$3,317	$212	1.07
76 Sagamore St.	31	1,100	9.3	2.1	$41,547	$3,795	$3,409	($386)	0.90
95 Sagamore St	31	1,000	9.6	1.8	$37,770	$3,450	$3,076	($374)	0.89
51 Agawam St.	31	900	5.7	5.7	$34,278	$3,131	$3,604	$473	1.15
62 Neponset St.	31	1,100	5.8	5.6	$41,896	$3,826	$4,969	$1.143	1.30
47 Bryant St.	31	1,200	11	0	$100,000	$9,133	$3,914	($5,220)	0.43
3 Arcadia St.	30	700	5.7	2.6	$26,439	$2,415	$3,397	$982	1.41
84 Arcadia St.	30	1,500	4.3	4	$56,655	$5,174	$3,615	($1,559)	0.70
15 York St.	12	1,100	4.6	3.7	$25,405	$2,320	$3,982	$1,662	1.72
38 Arcadia St.	31	1,300	9.1	0	$100,000	$9,133	$3,868	($5,265)	0.42
6 Lawrence St.	30	600	5.5	2.8	$22,662	$2,070	$3,397	$1,327	1.64
33 Ellerton St.	32	2,200	9.7	0	$100,000	$9,133	$3,328	($5,805)	0.36

TABLE 9: REVERE (CON'T)

14 Clinton Rd.	32	700	8.4	0	$100,000	$9,133	$3,696	($5,438)	0.40
96 Arcadia St.	32	1,000	6.3	2	$37,770	$3,450	$3,466	$16	1.00
98 Arcadia St.	32	1,000	5.7	2.6	$37,770	$3,450	$3,466	$16	1.00
15 Argyle St.	32	700	6.6	1.7	$26,439	$2,415	$3,420	$1,005	1.42
14 Lawrence St.	30	600	5.7	2.6	$22,662	$2,070	$3,397	$1,327	1.64
39 Arcadia St.	30	800	5	3.3	$30,216	$2,760	$3,902	$1,142	1.41
5 Argyle St.	30	1,400	6.2	2.1	$52,879	$4,829	$3,925	($904)	0.81
528 Revere Bch. Blvd.	31	1,200	14.1	0	$100,000	$9,133	$3,615	($5,518)	0.40
18 Lawrence St.	31	800	7.6	0.7	$100,000	$9,133	$3,638	($5,495)	0.40
572 Revere Bch. Blvd.	31	2,500	16.5	0	$100,000	$9,133	$3,569	($5,564)	0.39
784 North Shore Rd.	32	700	9.3	0	$100,000	$9,133	$4,625	($4,508)	0.51
41 Oak Island St.	31	1,500	11.9	0	$100,000	$9,133	$3,409	($5,725)	0.37
21 River Ave.	30	2,500	12.4	0	$100,000	$9,133	$4,200	($4,933)	0.46
Total for Bldgs. with BCR >= 1					$2,311,088	$211,075	$380,579	$169,505	1.80

Number of Bldgs. with BCR >= 1 62

Avg. Height to Raise Bldg. with BCR >=1 4.24

NOTE: ACTUAL BENEFITS & BCR's SHOWN.

TABLE 10

EAST SAUGUS

1/3

FLOOD PROOFING PLAN

HOUSE RAISING

PROJECT: SENE Saugus

TABLE 1: STRUCTURE TYPES

Wood Frame Single Story, Unfinished Basement	11
Wood Frame Single Story, Finished Basement	12
Brick or Masonry Single Story, Unfinished Basement	21
Brick or Masonry Single Story, Finished Basement	22
Single Story Slab-on-Grade	30
Wood Frame Two Story, Unfinished Basement	31
Wood Frame Two Story, Finished Basement	32

100 YR. LEVEL OF PROTECTION

ADDRESS	STRUCTURE TYPE (11-32)	FLOOR AREA (sf.)	FIRST FLOOR ELEV.	HT. TO RAISE BLDG.	FIRST COST	AVERAGE ANNUAL COST	SELECTED ANNUAL BENEFIT	NET BENEFIT	BCR
11 Soencer Ave.	31	1,250	9.3	1.7	$47,213	$4,312	$4,500	$188	1.04
18 Spencer Ave.	32	750	9.5	1.5	$28,328	$2,587	$4,000	$1.413	1.55
18 Milton St.	31	1,000	8.5	2.5	$37,770	$3,450	$4,500	$1,050	1.30
20 Milton St.	31	700	9.3	1.7	$26,439	$2,415	$4,500	$2,085	1.86
26 Ballard St.	31	750	9.6	1.4	$28,328	$2,587	$4,500	$1,913	1.74
28 Ballard St.	31	900	9.6	1.4	$33,993	$3,105	$4,500	$1,395	1.45
30 Ballard St.	21	1,000	9.7	1.3	$29,766	$2,719	$4,000	$1,281	1.47
32 Ballard St.	31	1,000	9.8	1.2	$37,770	$3,450	$4,500	$1,050	1.30
38 Ballard St.	31	900	9.9	1.1	$33,993	$3,105	$4,500	$1,395	1.45
40 Ballard St.	31	1,000	10	1	$37,770	$3,450	$4,500	$1,050	1.30
58 Ballard St.	31	1,350	9.9	1.1	$50,990	$4,657	$4,500	($157)	0.97
14 Spencer Ave.	31	1,000	9.6	1.4	$37,770	$3,450	$4,500	$1,050	1.30
49 Ballard St.	31	750	9.9	1.1	$28,328	$2,587	$4,500	$1,913	1.74
33 Ballard St.	31	900	10	1	$33,993	$3,105	$4,500	$1,395	1.45
31 Ballard St.	31	650	9.9	1.1	$24,551	$2,242	$4,500	$2,258	2.01
27 Ballard St.	31	900	9.8	1.2	$33,993	$3,105	$4,500	$1,395	1.45
23 Ballard St.	31	1,600	9.7	1.3	$60,432	$5,519	$4,500	($1,019)	0.82
19 Ballard St.	31	1,800	9.6	1.4	$67,986	$6,209	$4,500	($1,709)	0.72
23 Henry St.	32	1,200	8.3	2.4	$45,324	$4,140	$4,000	($140)	0.97

TABLE 10: SAUGUS Continued

21 Henry St.	31	1,200	8.8	1.9	$45,324	$4,140	$4,500	$360	1.09
17 Henry St.	32	1,000	9.6	1.1	$37,770	$3,450	$4,000	$550	1.16
28 Dudly St.	31	900	9.1	1.6	$33,993	$3,105	$4,500	$1,395	1.45
25 Dustin St.	31	1,100	9.4	1.3	$41,547	$3,795	$4,500	$705	1.19
27 Dustin St.	32	1,000	9	1.7	$37,770	$3,450	$4,000	$550	1.16
29 Dustin St.	32	1,200	9	1.7	$45,324	$4,140	$4,000	($140)	0.97
5 Eckstrand St.	32	1,700	8.8	1.9	$64,209	$5,864	$4,000	($1,864)	0.68
28 Dustin St.	31	1,200	9	1.7	$45,324	$4,140	$4,500	$360	1.09
26 Dustin St.	31	1,200	8.6	2.1	$45,324	$4,140	$4,500	$360	1.09
24 Dustin St.	31	900	9.6	1.1	$33,993	$3,105	$4,500	$1,395	1.45
22 Dustin St.	31	1,050	9.6	1.1	$39,659	$3,622	$4,500	$878	1.24
38 Wickford St.	31	1,000	8.9	1.8	$37,770	$3,450	$4,500	$1,050	1.30
40 Wickford St.	22	1,600	9.6	1.1	$47,626	$4,350	$4,000	($350)	0.92
9 Althorn St.	22	1,500	9.3	1.4	$44,649	$4,078	$4,000	($78)	0.98
45 Sebino Way	22	1,500	9.6	1.1	$44,649	$4,078	$4,000	($78)	0.98
22 Sebino Way	32	1,250	9.7	1	$47,213	$4,312	$4,000	($312)	0.93
48 Sebino Way	32	1,550	9.1	1.6	$58,544	$5,347	$4,000	($1,347)	0.75
52 Sebino Way	30	1,350	8.9	1.8	$50,990	$4,657	$5,000	$343	1.07
61 Halstead St.	32	1,200	8.9	1.8	$45,324	$4,140	$4,000	($140)	0.97
63 Halstead St.	32	1,500	7.7	3	$56,655	$5,174	$4,000	($1,174)	0.77
65 Halstead St.	31	1,600	7.4	3.3	$60,432	$5,519	$4,500	($1,019)	0.82
67 Halstead St.	30	1,250	8.1	2.6	$47,213	$4,312	$5,000	$686	1.16
62 Halstead St.	31	1.150	9.2	1.5	$43.436	$3,967	$4.500	$533	1.13
8 Mersea Rd.	32	900	7.7	3	$33,993	$3,105	$4,000	$895	1.29
4 Mersea Rd.	32	900	7.2	3.5	$33,993	$3,105	$4,000	$895	1.29
3 Mersea Rd.	22	1,600	8.2	2.5	$47,626	$4,350	$4,000	($350)	0.92
7 Mersea Rd.	31	1,000	8.1	2.6	$37,770	$3,450	$4,500	$1,050	1.30
11 Mersea Rd.	21	1,500	8.3	2.4	$44,649	$4,078	$4,000	($78)	0.98
28 Carr Rd.	32	1,100	9.5	1.2	$41,547	$3,795	$4,000	$205	1.05
29 Carr Rd.	32	1,000	9.5	1.2	$37,770	$3,450	$4,000	$550	1.16
26 Pevwell Dr.	32	1,750	9.6	1.1	$66,098	$6,037	$4,000	($2,037)	0.66
24 Pevwell Dr.	32	1,800	9.6	1.1	$67,986	$6,209	$4,000	($2,209)	0.64
22 Pevwell Dr.	32	1,550	9.5	1.2	$58,544	$5,347	$4,000	($1,347)	0.75
30 Pevwell Dr.	32	1,200	8.6	2.1	$45,324	$4,140	$4,000	($140)	0.97
18 Pevwell Dr.	32	2,800	7.5	3.2	$105,757	$9,659	$4,000	($5,659)	0.41
16 Pevwell Dr.	32	1,500	7.5	3.2	$56,655	$5,174	$4,000	($1,174)	0.77
14 Pevwell Dr.	32	1,750	8	2.7	$66,098	$6,037	$4,000	($2,037)	0.66
12 Pevwell Dr.	30	2,100	8.7	2	$79,318	$7,244	$5,000	($2,244)	0.69
10 Pevwell Dr.	32	1,750	9	1.7	$66,098	$6,037	$4,000	($2,037)	0.66
8 Pevwell Dr.	32	1,500	9.2	1.5	$56,655	$5,174	$4,000	($1,174)	0.77
23 Pevwell Dr.	32	1,100	7.2	3.5	$41,547	$3,795	$4,000	$205	1.05
21 Pevwell Dr.	32	1,100	7.1	3.6	$41,547	$3,795	$4,000	$205	1.05
19 Pevwell Dr.	32	1,250	6.7	4	$47,213	$4,312	$4.000	($312)	0.93
17 Pevwell Dr.	32	1,200	8.9	1.8	$45.324	$4,140	$4,000	($140)	0.97
15 Pevwell Dr.	32	1,000	9.3	1.4	$37,770	$3,450	$4.000	$550	1.16
11 Pevwell Dr.	32	700	9.5	1.2	$26,439	$2,415	$4,000	$1,585	1.66
9 Pevwell Dr.	32	1,250	9.4	1.3	$47,213	$4,312	$4,000	($312)	0.93
53 Gates Rd.	32	1,500	8.1	2.6	$56,655	$5,174	$4,000	($1,174)	0.77
47 Gates Rd.	31	800	7.5	3.2	$30,216	$2,760	$4,500	$1,740	1.63
39 Gates Rd.	22	1,050	8.5	2.2	$31,254	$2,854	$4,000	$1,146	1.40
25 Gates Rd.	31	900	9.2	1.5	$33,993	$3,105	$4,500	$1,395	1.45
6 Gates Rd.	32	900	9.7	1	$33,993	$3,105	$4,000	$895	1.29
18 Gates Rd.	31	900	8.9	1.8	$33,993	$3,105	$4,500	$1,395	1.45
26 Gates Rd.	32	900	8.9	1.8	$33,993	$3,105	$4,000	$895	1.29
32 Gates Rd.	31	1,650	8.3	2.4	$62,321	$5,692	$4,500	($1,192)	0.79
34 Gates Rd.	22	900	8.8	1.9	$26,789	$2,447	$4,000	$1,553	1.63

TABLE 10: SAUGUS Continued 3/3

36 Gates Rd.	22	900	8.9	1.8	$26,789	$2,447	$4,000	$1,553	1.63
40 Gates Rd.	32	650	9	1.7	$24,551	$2,242	$4,000	$1,758	1.78
44 Gates Rd.	32	1,500	9.2	1.5	$56,655	$5,174	$4,000	($1,174)	0.77
48 Gates Rd.	22	1,200	9.4	1.3	$35,719	$3,262	$4,000	$738	1.23
11 Guild Rd.	32	1,100	9	1.7	$41,547	$3,795	$4,000	$205	1.05
17 Guild Rd.	21	1,050	9	1.7	$31,254	$2,854	$4,000	$1,146	1.40
19 Guild Rd.	31	1,000	9	1.7	$37,770	$3,450	$4,500	$1,050	1.30
22 Guild Rd.	22	1,050	9	1.7	$31,254	$2,854	$4,000	$1,146	1.40
23 Guild Rd.	32	900	9	1.7	$33,993	$3,105	$4,000	$895	1.29
24 Guild Rd.	31	750	9	1.7	$28,328	$2,587	$4,500	$1,913	1.74
26 Guild Rd.	32	1,650	9	1.7	$62,321	$5,692	$4,000	($1,692)	0.70
30 Guild Rd.	32	2,250	9	1.7	$84,983	$7,762	$4,000	($3,762)	0.52
31 Guild Rd.	22	1,600	9	1.7	$47,626	$4,350	$4,000	($350)	0.92
======									
7 Lindsell St.	31	1,250	9.4	1.1	$47,213	$4,312	$4,500	$188	1.04
25 Beachview St.	32	1,100	9.2	1.3	$41,547	$3,795	$4,000	$205	1.05
7 Belair St.	11	1,150	8.6	1.9	$26,560	$2,426	$4,000	$1,574	1.65
19 Atlas Ave.	32	2,200	9.4	1.1	$83,095	$7,589	$4,000	($3,589)	0.53
25 Naples St. AVE	32	550	9.3	1.2	$20,774	$1,897	$4,000	$2,103	2.11
26 Naples St.	32	800	9.5	1	$30,216	$2,760	$4,000	$1,240	1.45
23 Seagrit Ave.	32	1,250	8.7	1.8	$47,213	$4,312	$4,000	($312)	0.93
25 Seagrit Ave.	22	1,300	8.8	1.7	$38,696	$3,534	$4,000	$466	1.13
35 Seagrit Ave.	32	1,500	6.9	3.6	$56,655	$5,174	$4,000	($1,174)	0.77
45 Seagrit Ave.	32	2,100	9	1.5	$79,318	$7,244	$4,000	($3,244)	0.55
53 Seagrit Ave.	22	800	8.9	1.6	$23,813	$2,175	$4,000	$1,825	1.84
55 Seagrit Ave.	32	1,900	8.7	1.8	$71,763	$6,554	$4,000	($2,554)	0.61
44 Seagrit Ave.	32	1,500	9.1	1.4	$56,655	$5,174	$4,000	($1,174)	0.77
42 Seagrit Ave.	32	1,650	7.8	2.7	$62,321	$5,692	$4,000	($1,692)	0.70
34 Seagrit Ave.	32	1,350	8	2.5	$50,990	$4,657	$4,000	($657)	0.86
32 Seagrit Ave.	32	1,350	8.3	2.2	$50,990	$4,657	$4,000	($657)	0.86
26 Seagrit Ave.	31	2,400	8.4	2.1	$90,649	$8,279	$4,500	($3,779)	0.54
22 Seagrit Ave.	32	3,500	8.8	1.7	$132,196	$12,074	$4,000	($8,074)	0.33
18 Seagrit Ave.	32	600	9.2	1.3	$22,662	$2,070	$4,000	$1,930	1.93
14 Seagrit Ave.	32	1,600	8.4	2.1	$60,432	$5,519	$4,000	($1,519)	0.72
12 Seagrit Ave.	32	600	8.6	1.9	$22,662	$2,070	$4,000	$1,930	1.93
8 Seagrit Ave.	22	1,250	8.6	1.9	$37,207	$3,398	$4,000	$602	1.18
19 Venice Ave.	30	1,250	9	1.5	$47,213	$4,312	$5,000	$688	1.16
21 Venice Ave.	32	1,500	8.9	1.6	$56,655	$5,174	$4,000	($1,174)	0.77
23 Venice Ave.	30	2,000	8.6	1.9	$75,541	$6,899	$5,000	($1,899)	0.72
25 Venice Ave.	32	2,000	8.6	1.9	$75,541	$6,899	$4,000	($2,899)	0.58
29 Venice Ave.	32	1,350	8.7	1.8	$50,990	$4,657	$4,000	($657)	0.86
31 Venice Ave.	32	800	8.4	2.1	$30,216	$2,760	$4,000	$1,240	1.45
33 Venice Ave.	32	1,350	8.4	2.1	$50,990	$4,657	$4,000	($657)	0.86
22 Venice Ave.	30	1,500	8.8	1.7	$56,655	$5,174	$5,000	($174)	0.97
50 Bristow St.	32	1,600	9.5	1	$60,432	$5,519	$4,000	($1,519)	0.72
11 Bristow St.	21	1,500	9.1	1.4	$44,649	$4,078	$4,000	($78)	0.98
65 Bristow St.	32	1,800	9.2	1.3	$67,986	$6,209	$4,000	($2,209)	0.64
22 Bristow St.	22	1,000	9.4	1.1	$29,766	$2,719	$4,000	$1,281	1.47
60 Bristow St.	30	1,500	9.2	1.3	$56,655	$5,174	$5,000	($174)	0.97
68 Bristow St.	32	800	9.2	1.3	$30,216	$2,760	$4,000	$1,240	1.45
72 Bristow St.	30	1,350	9.2	1.3	$50,990	$4,657	$5,000	$343	1.07
82 Bristow St.	31	950	9.2	1.3	$35,882	$3,277	$4,500	$1,223	1.37
Total for Bldgs. with BCR >= 1					$2,423,570	$221,348			

Number of Bldgs. with BCR >= 1 69

Avg. Height to Raise Bldg. with BCR >=1 1.67

Adjusted Annual Benefit & BCR : | $465,410 | 2.10 |

TABLE 11

LYNN

1/2

FLOOD PROOFING PLAN

HOUSE RAISING
++++++++++++++++++++

PROJECT: SENE Lynn

TABLE 1: STRUCTURE TYPES

Wood Frame Single Story, Unfinished Basement	11
Wood Frame Single Story, Finished Basement	12
Brick or Masonry Single Story, Unfinished Basement	21
Brick or Masonry Single Story, Finished Basement	22
Single Story Slab-on-Grade	30
Wood Frame Two Story, Unfinished Basement	31
Wood Frame Two Story, Finished Basement	32

100 YR. LEVEL OF PROTECTION

ADDRESS	STRUCTURE TYPE (11-32)	FLOOR AREA (sf.)	FIRST FLOOR ELEV.	HT. TO RAISE BLDG.	FIRST COST	AVERAGE ANNUAL COST	SELECTED ANNUAL BENEFIT	NET BENEFIT	BCR
30-32 Norton St.	31	1,150	10.4	2	$43,436	$3,967	$4,500	$533	1.13
33 Norton St.	31	750	10.2	2.2	$28,328	$2,587	$4,500	$1,913	1.74
28 Varnum St.	31	1,050	10.7	1.7	$39,659	$3,622	$4,500	$878	1.24
30 Varnum St.	31	1,100	10.8	1.6	$41,547	$3,795	$4,500	$705	1.19
11 Ray St.	31	1,600	11.4	1	$60,432	$5,519	$4,500	($1,019)	0.82
81 Light St.	31	600	11	1.4	$22,662	$2,070	$4,500	$2,430	2.17
83 Light St.	31	700	10.8	1.6	$26,439	$2,415	$4,500	$2,085	1.86
92 Light St.	31	950	9.9	2.5	$35,882	$3,277	$4,500	$1,223	1.37
50 W. Neptune St.	31	1,150	11.4	1	$43,436	$3,967	$4,500	$533	1.13
26 Richard St.	31	850	9.6	2.8	$32,105	$2,932	$4,500	$1,568	1.53
9-11 Elmwood Ave.	31	600	11	1.4	$22,662	$2,070	$4,500	$2,430	2.17
44 Elmwood Ave.	31	750	11.4	1	$28,328	$2,587	$4,500	$1,913	1.74
48 Elmwood Ave.	31	750	11.3	1.1	$28,328	$2,587	$4,500	$1,913	1.74
50-52 Elmwood Ave.	31	1,350	10.7	1.7	$50,990	$4,657	$4,500	($157)	0.97
68 Elmwood Ave.	31	850	10.8	1.6	$32,105	$2,932	$4,500	$1,568	1.53
69 Elmwood Ave.	31	1,900	10.9	1.5	$71,763	$6,554	$4,500	($2,054)	0.69
100 Orchard St.	31	1,100	11.3	1.1	$41,547	$3,795	$4,500	$705	1.19
105 Orchard St.	31	750	10.9	1.5	$28,328	$2,587	$4,500	$1,913	1.74
103 Oakville St.	31	850	11.3	1.1	$32,105	$2,932	$4,500	$1,568	1.53

TABLE 11: LYNN Con't. 2/2

167 Neptune St.	31	600	11.3	1.1	$22,662	$2,070	$4,500	$2,430	2.17
69 Lowell St.	31	1,100	10.3	2.1	$41,547	$3,795	$4,500	$705	1.19
80 Lowell St.	31	1,050	9.6	2.8	$39,659	$3,622	$4,500	$878	1.24
66 South Elm St.	31	800	10.8	1.6	$30,216	$2,760	$4,500	$1,740	1.63
79 South Elm St.	31	800	10.5	1.9	$30,216	$2,760	$4,500	$1,740	1.63
83 South Elm St.	31	700	10.9	1.5	$26,439	$2,415	$4,500	$2,085	1.86
67 Astor St.	31	800	11.3	1.1	$30,216	$2,760	$4,500	$1,740	1.63
72 Astor St.	31	850	10.8	1.6	$32,105	$2,932	$4,500	$1,568	1.53
151 Alley St.	31	500	10.8	1.6	$18,885	$1,725	$4,500	$2,775	2.61
166 Alley St.	31	1,150	10.8	1.6	$43,436	$3,967	$4,500	$533	1.13
182 Alley St.	31	1,100	9.2	3.2	$41,547	$3,795	$4,500	$705	1.19
=====================									
65 Camden St.	31	400	9.2	1.1	$15,108	$1,380	$4,500	$3,120	3.26
Total for Bldgs. with BCR >= 1					$898,932	$82,101			

Number of Bldgs. with BCR >= 1 28

Avg. Height to Raise Bldg. with BCR >= 1 1.67 ft.

Adjusted Annual Benefit & BCR : $230,160 2.80

OPTION #3 - REGIONAL SAUGUS RIVER FLOODGATE PLAN

GENERAL - The Regional Saugus River Floodgate Plan (Option 3) or Regional Plan (Plate R15) was described, as follows, at the start of the public involvement process early in the study. It would include floodgates across the mouth of the Saugus River either upstream or downstream of the General Edwards Bridge tied into existing or new shorefront protection (e.g. walls, dikes, revetments) along Revere's shorefront and Lynn Harbor to reduce wave overtopping. A separate plan was being considered to protect an area behind Lynn Beach. The floodgates would be closed two or three times a year generally for only a few hours each time to prevent tidal surges and flooding up the Saugus and Pines Rivers to the entire study area. The gates would be opened as the tides recede. The general design criteria at the beginning of the study for the Regional Plan gates are that they should:

(1) maintain the natural flushing and tide levels in the estuary; and

(2) maintain safe passage for navigation.

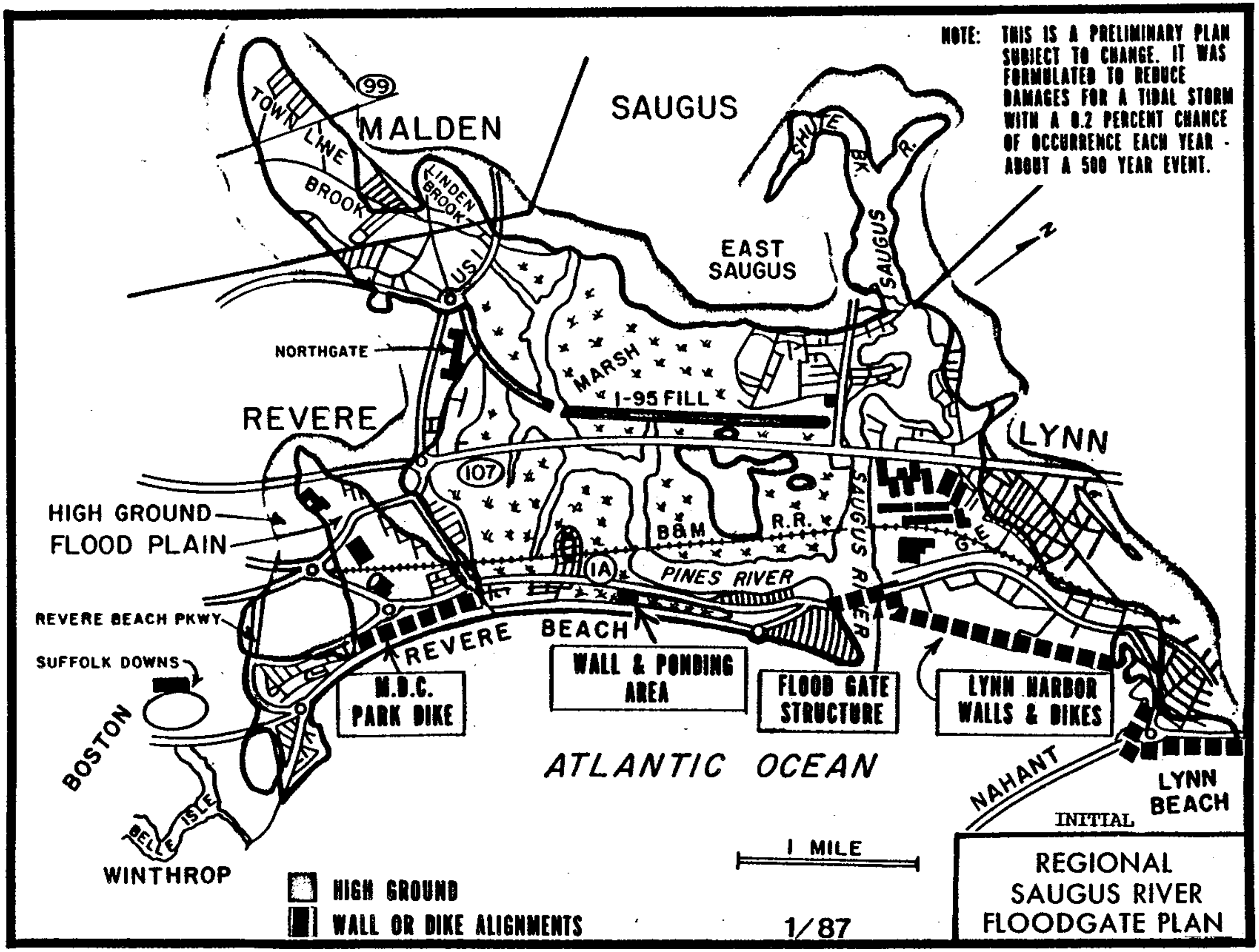
Thus, there should be no significant change in the estuary or navigation passage when the gates are open. In the closed position, preliminary indications were there would be benefits to navigation as a port of refuge, and there would be no significant impact on the estuary due to the short length of time gates would be closed and infrequency of closure.

The Plan would provide a high degree of flood protection to the 5000 residential, commercial and industrial buildings in the Saugus River and Tributaries floodplain of Lynn, Malden, Revere and Saugus against coastal storms. The Boston metropolitan area would also benefit from protection of several Northshore transportation arteries and from recreational parkland developed along the historic Revere Beach Reservation. The Regional Plan would also reduce the deterioration, erosion and replacement or repair costs to many miles of existing shorefront and structures bordering developed properties around the estuary.

The estuary would serve as a natural flood water storage area to further prevent damages during coastal storm events coincident with runoff. The estuary would store both storm tide water allowed to overtop the shorefront and runoff from the Saugus River watershed.

Initial Plans - The initial preliminary plans were investigated to determine potential economic, environmental, technical and social feasibility. The plans and information was provided in a Working Document to Citizen Steering Committees and Technical Group to obtain as many concerns as possible at the start of the study. When the potential was realized for a Regional Plan, and at that time, the strong interest in preserving the estuarys' resources, the main criteria was developed for the Regional Plan's gates.

PLATE R-15



OPTION #3

Three general locations for a floodgate were considered for "initial" review by the Corps and public study teams; including the mouth of the Saugus River, the mouth of the Pines River, and near the B&M bridge on the Pines River.

(a) Regional Saugus River Floodgate Plan - Five potential alignments at the mouth of the Saugus River were identified however only one was selected for preliminary evaluation of this plan (Plate R16). An alignment (no. 4) immediately west of the General Edwards Bridge was used since it would not significantly impact the neighborhood of Point of Pines which had their own flood damage reduction project under design at that time. It would also have no impact on the proposed South Harbor Development Project, both on the opposite side of the bridge. However, the impacts on real estate West of the bridge were estimated at about $2 million higher than the east side and other potential impacts would need to be looked into further. The plan included: the floodgate, dikes and walls along Lynn Harbor and Lynn Beach, a park dike and ponding area behind Revere Beach (Plates R17-19). Two options were considered for the floodgate structure either having it span the river with a gated wall, or both dikes and a gated wall. The plan would protect the entire study area. The floodgates were <u>initially</u> sized to provide safe flows for navigation during a <u>mean tide range</u>. The 14 -(10'x 16.6') flushing slide gates had a total opening of 2324 square feet (SF). The navigation miter gate and flushing gates had a flow area at mid or peak tide of 2534 SF below EL. 0.0. During a mean tide range there should be no significant change in the estuary.

(b) Pines River Floodgate Plan (Plates 20 & 21) includes: a floodgate at the mouth of the Pines River, walls and dikes to East Saugus; walls along the Saugus River to the General Edwards Bridge, and the park dike and ponding area behind Revere Beach. The plan would protect Revere Beach Backshore, Northgate, Town Line Brook area and East Saugus. Not protected were the city of Lynn and upper Saugus River and Shute Brook areas. The plan would provide no benefit or impacts on the Saugus River.

(c) Pines River B & M Floodgate Plan (Plates 22 and 23) includes: a floodgate across the Pines River, east of the B + M railroad bridge; connected to walls and dikes to East Saugus; walls and dikes along the Pines and Saugus Rivers to General Edwards Bridge; and the park dike and ponding area are behind Revere Beach. The plan would protect the same area as the floodgate plan at the mouth of the Pines River. However, this plan would not benefit navigation or impact traffic on either the Saugus or Pines Rivers.

<u>Table 12</u> compares the feasibility of the initial plans, at the beginning of the study, when first discussed with the committees to obtain comments.

From the very start wide support was voiced for the Regional Plan and opposition to the two Pines River Plans, Local Protection Plans and Nonstructural Plan since they did not protect the entire area and some caused significant impact on wetland. The two Pines River Plans were screened out for these reasons and their lower net economic benefits.

The initial Options 1 and 2 plans underwent some additional revisions previously explained. Option 3 proceeded into more detailed planning and analysis since it produced the highest new economic benefits and was the only plan strongly supported by the sponsoring communities, Congressmen and several agencies provided it did not harm the estuary.

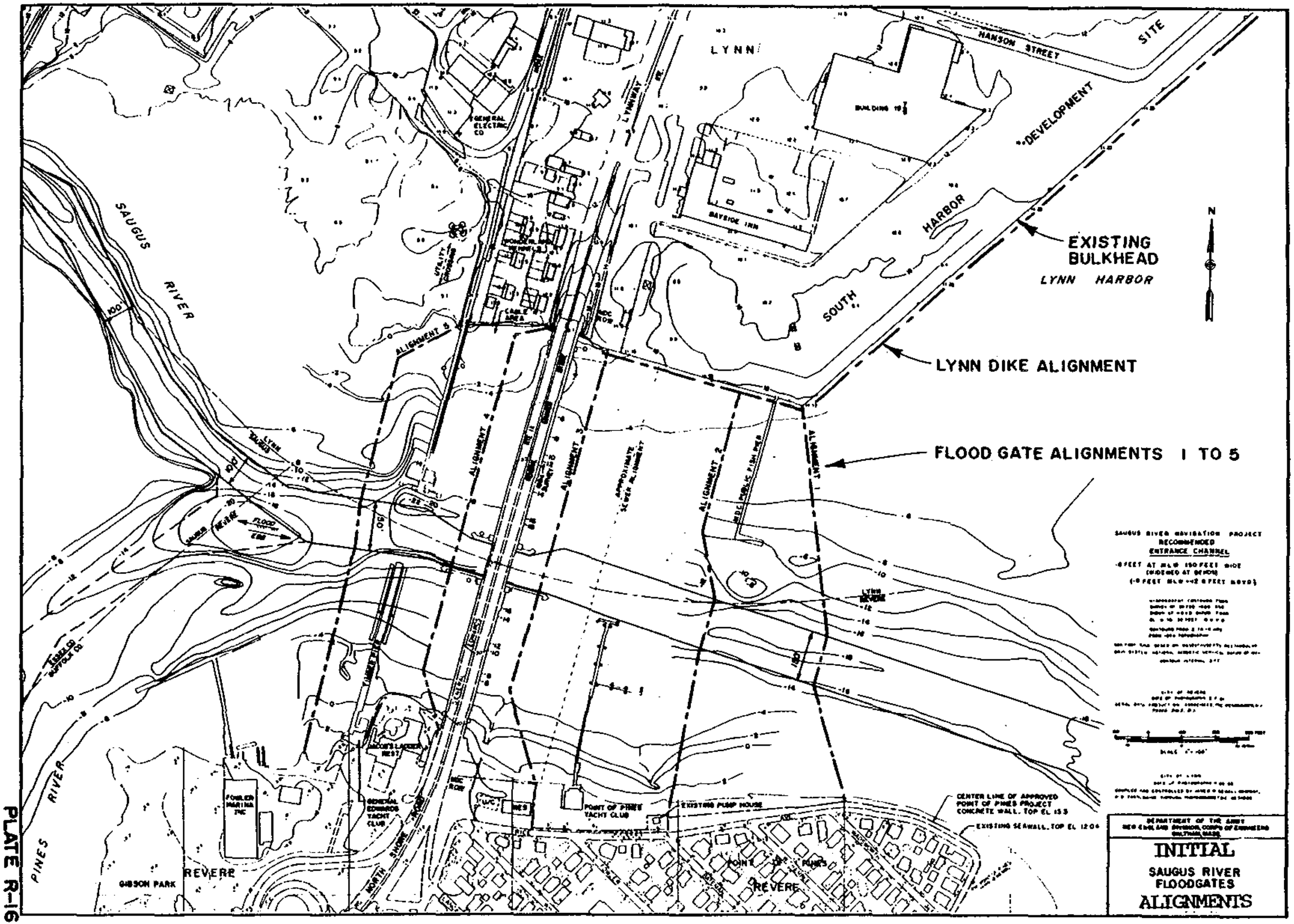
TABLE 12

COMPARISON OF INITIAL PLANS AT BEGINNING OF STUDY
(1985 Price Levels)

Plan	Estimated Buildings Protected (Number)	Average Annual 1/ Benefits ($1000)	Average Annual Net Benefits ($1000)	Project First Cost ($Million)	Impacted Vegetated Wetlands (Acres)	Impacted Coastal Mudflats Riverbank (Acres)
Initial Local Protection Plans						
Option 1A (Four LLP's) 2/	4150	$6830	$2530	$44	31	32
Option 1B (Three LPP's excluding E.Saugus)	3600	$5940	$2050	$40	7	21
Initial Nonstructural Plans						
Revere Beach Backshore	58	$ 328	$ 138	$2.2	0	0
Other Areas:	Less than 5% (NOT DETERMINED)					
Initial Regional Saugus River Floodgate Plan						
Option 3A (Dike & Wall)	5000	$7100	$3640	$34	0	14
Option 3B (Wall only at Floodgate)	5000	$7100	$2720	$43	0	13
Initial Pines River Floodgate Plan						
(excludes Lynn and Upper Saugus River areas)	2900	$3137	$ 637	$24	10	5
Initial Pines River B&M Floodgate Plan						
(excludes Lynn and Upper Saugus River areas)	2900	$3137	$ 17	$30	15	10

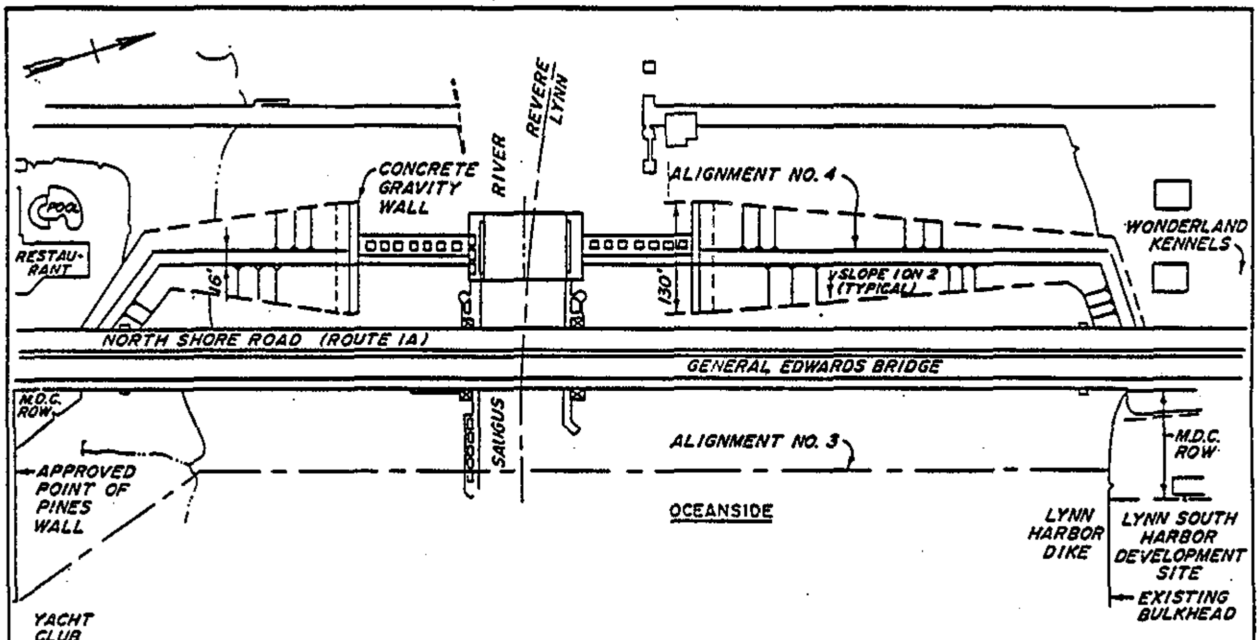
1/ Benefits included only reduction in flood inundation.

2/ Four LPP's include Revere Beach Backshore, Lynn, East Saugus and Town Line Brook.



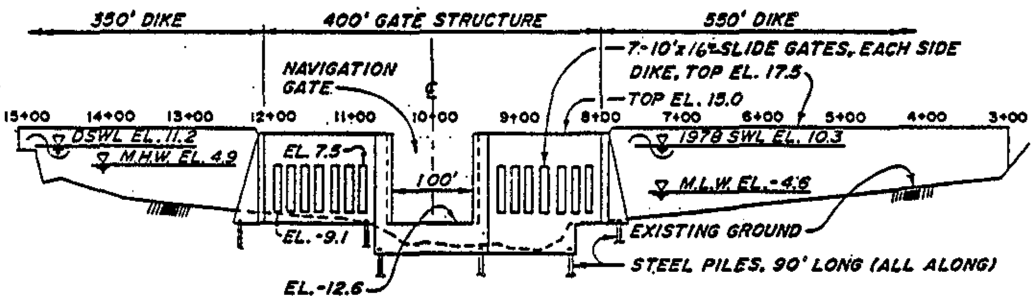
LYNN
HANSON STREET
SITE
DEVELOPMENT
HARBOR
SOUTH
BUILDING 19
BAYSIDE INN
GENERAL ELECTRIC CO
LYNNWAY
SAUGUS RIVER
EXISTING BULKHEAD
LYNN HARBOR
LYNN DIKE ALIGNMENT
FLOOD GATE ALIGNMENTS 1 TO 5
ALIGNMENT 1
ALIGNMENT 2
ALIGNMENT 3
ALIGNMENT 4
ALIGNMENT 5
APPROXIMATE SEWER ALIGNMENT
FLOOD
EBB
PINES RIVER
GIBSON PARK
REVERE
FOWLER MARINA INC
GENERAL EDWARDS YACHT CLUB
JACOB'S LADDER REST
NORTH SHORE ROAD
POINT OF PINES YACHT CLUB
EXISTING PUMP HOUSE
CENTER LINE OF APPROVED POINT OF PINES PROJECT CONCRETE WALL, TOP EL 13.5
EXISTING SEAWALL, TOP EL 12.0±
POINT OF PINES
REVERE
SAUGUS RIVER NAVIGATION PROJECT
RECOMMENDED ENTRANCE CHANNEL
DEPARTMENT OF THE ARMY
INITIAL
SAUGUS RIVER FLOODGATES
ALIGNMENTS

PLATE R-16



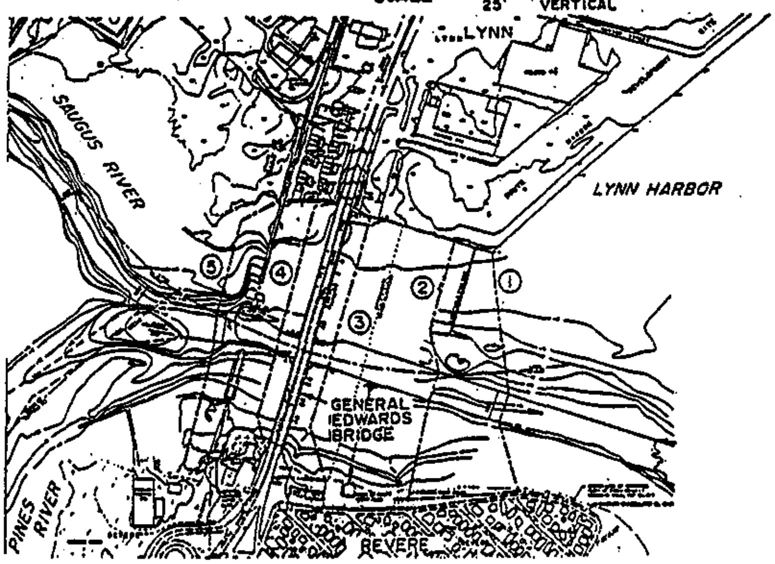
FLOOD GATE PLAN

SCALE: 100'



FLOOD GATE PROFILE

SCALE: 100' HORIZONTAL, 25' VERTICAL



FLOOD GATE ALTERNATE ALIGNMENTS

SCALE: 400'

500 YEAR

DSWL = DESIGN STILLWATER LEVEL

ELEVATIONS = FT. (N.G.V.D.)

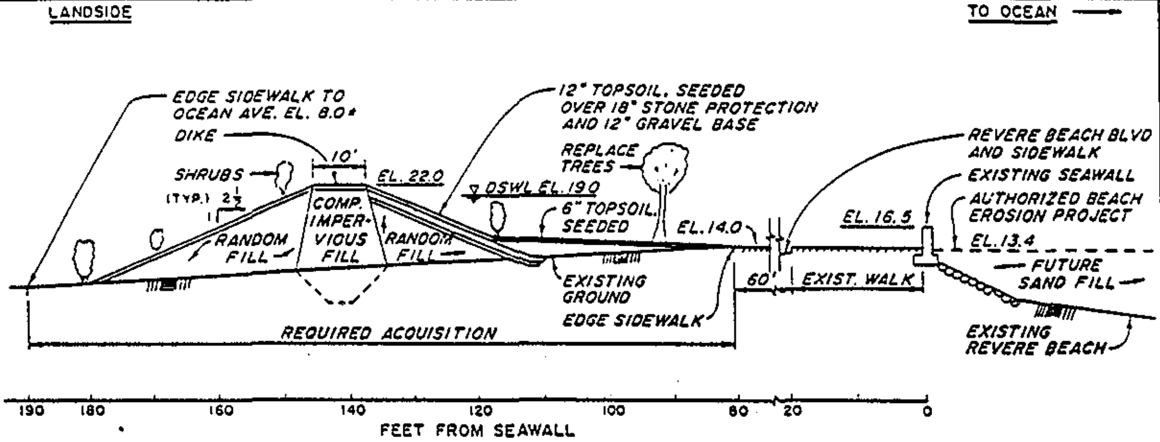
INITIAL

REGIONAL SAUGUS RIVER FLOODGATE PLAN

ALIGNMENT NO. 4

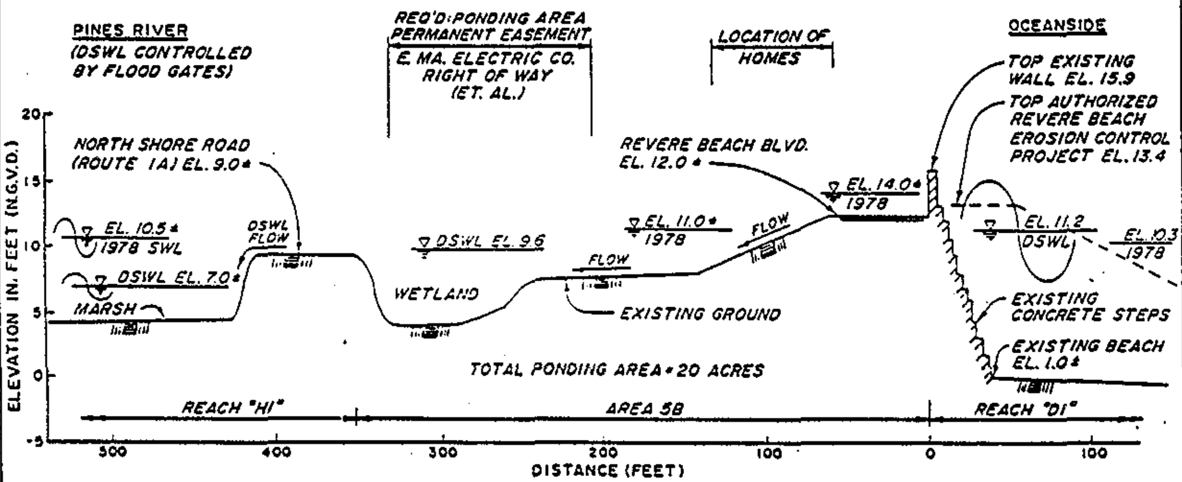
DECEMBER 1981

PLATE R-17



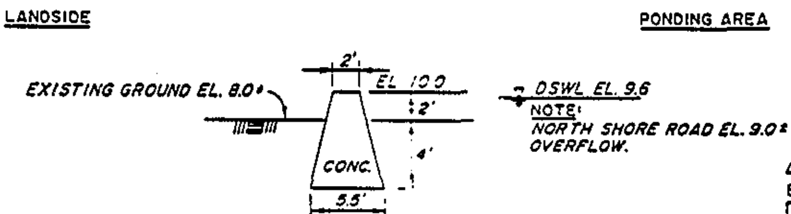
REACHES "B5" AND "B7" - M.D.C. PARK DIKE & 8.5 ACRES ACQUISITION

INCLUDES RAMP ON BLVD. AT SOUTH END OF DIKE NEAR BEACH STREET
AND A RAMP OVER DIKE AT NORTH SIDE OF POLICE STATION



NORTH SHORE ROAD - PONDING AREA - PERMANENT EASEMENT - 11 ACRES

REACHES A, B, C & D - MAINTAIN EXISTING SEAWALLS AND BEACH



500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)

CONCRETE GRAVITY WALL - REACH "M"

SOUTH END OF PONDING AREA

INITIAL
REGIONAL
FLOODGATE PLAN
OPTION 3
REVERE BEACH FEATURES
DECEMBER 1986

PLATE R-18

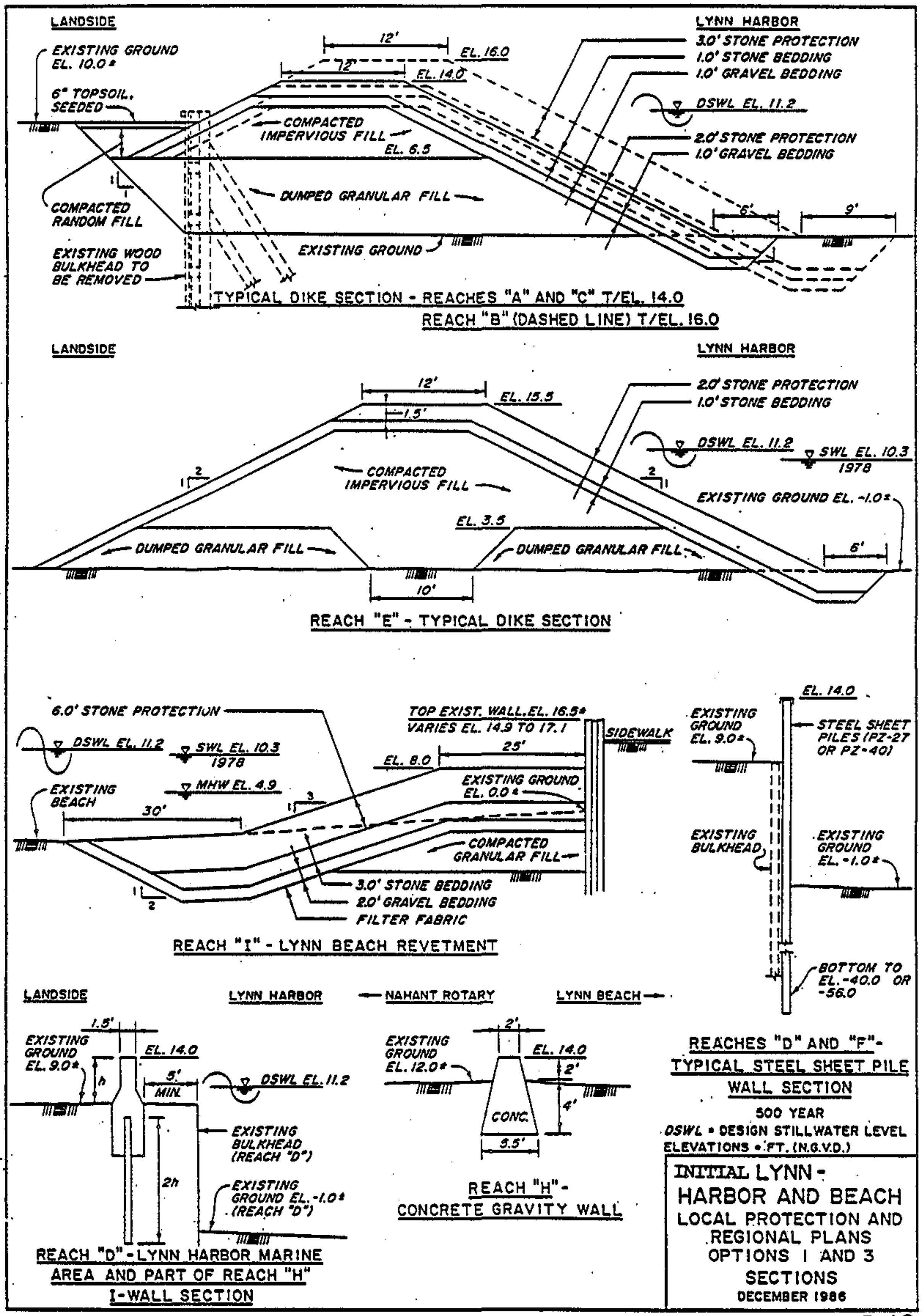

LANDSIDE
LYNN HARBOR
EXISTING GROUND EL. 10.0±
6" TOPSOIL, SEEDED
12'
EL. 16.0
12'
EL. 14.0
3.0' STONE PROTECTION
1.0' STONE BEDDING
1.0' GRAVEL BEDDING
DSWL EL. 11.2
COMPACTED IMPERVIOUS FILL
EL. 6.5
2.0' STONE PROTECTION
1.0' GRAVEL BEDDING
COMPACTED RANDOM FILL
DUMPED GRANULAR FILL
6'
9'
EXISTING WOOD BULKHEAD TO BE REMOVED
EXISTING GROUND
TYPICAL DIKE SECTION - REACHES "A" AND "C" T/EL. 14.0
REACH "B" (DASHED LINE) T/EL. 16.0
LANDSIDE
LYNN HARBOR
12'
EL. 15.5
1.5'
2.0' STONE PROTECTION
1.0' STONE BEDDING
DSWL EL. 11.2
SWL EL. 10.3 1978
COMPACTED IMPERVIOUS FILL
EXISTING GROUND EL. -1.0±
EL. 3.5
DUMPED GRANULAR FILL
DUMPED GRANULAR FILL
6'
10'
REACH "E" - TYPICAL DIKE SECTION
6.0' STONE PROTECTION
TOP EXIST. WALL EL. 16.5±
VARIES EL. 14.9 TO 17.1
SIDEWALK
DSWL EL. 11.2
SWL EL. 10.3 1978
EL. 8.0
25'
EXISTING GROUND EL. 0.0±
MHW EL. 4.9
EXISTING BEACH
30'
COMPACTED GRANULAR FILL
3.0' STONE BEDDING
2.0' GRAVEL BEDDING
FILTER FABRIC
REACH "I" - LYNN BEACH REVETMENT
EL. 14.0
EXISTING GROUND EL. 9.0±
STEEL SHEET PILES (PZ-27 OR PZ-40)
EXISTING BULKHEAD
EXISTING GROUND EL. -1.0±
BOTTOM TO EL. -40.0 OR -56.0
REACHES "D" AND "F" - TYPICAL STEEL SHEET PILE WALL SECTION
LANDSIDE
LYNN HARBOR
NAHANT ROTARY
LYNN BEACH
1.5'
EXISTING GROUND EL. 9.0±
EL. 14.0
h
5' MIN.
DSWL EL. 11.2
EXISTING BULKHEAD (REACH "D")
2h
EXISTING GROUND EL. -1.0± (REACH "D")
REACH "D" - LYNN HARBOR MARINE AREA AND PART OF REACH "H" I-WALL SECTION
2'
EXISTING GROUND EL. 12.0±
EL. 14.0
2'
4'
CONC.
3.5'
REACH "H" - CONCRETE GRAVITY WALL
500 YEAR
DSWL = DESIGN STILLWATER LEVEL
ELEVATIONS = FT. (N.G.V.D.)
INITIAL LYNN - HARBOR AND BEACH
LOCAL PROTECTION AND REGIONAL PLANS
OPTIONS 1 AND 3
SECTIONS
DECEMBER 1986

PLATE R-19

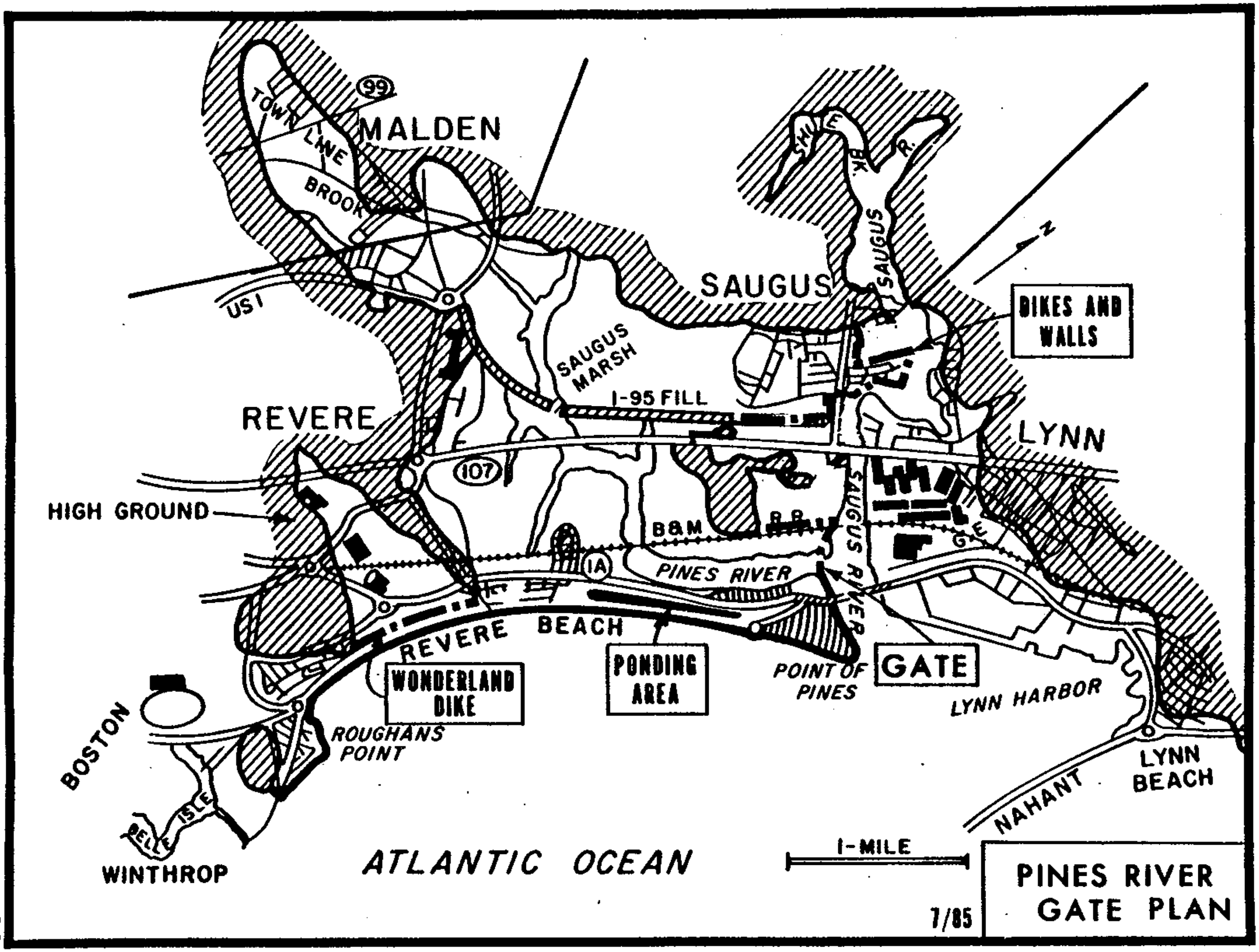
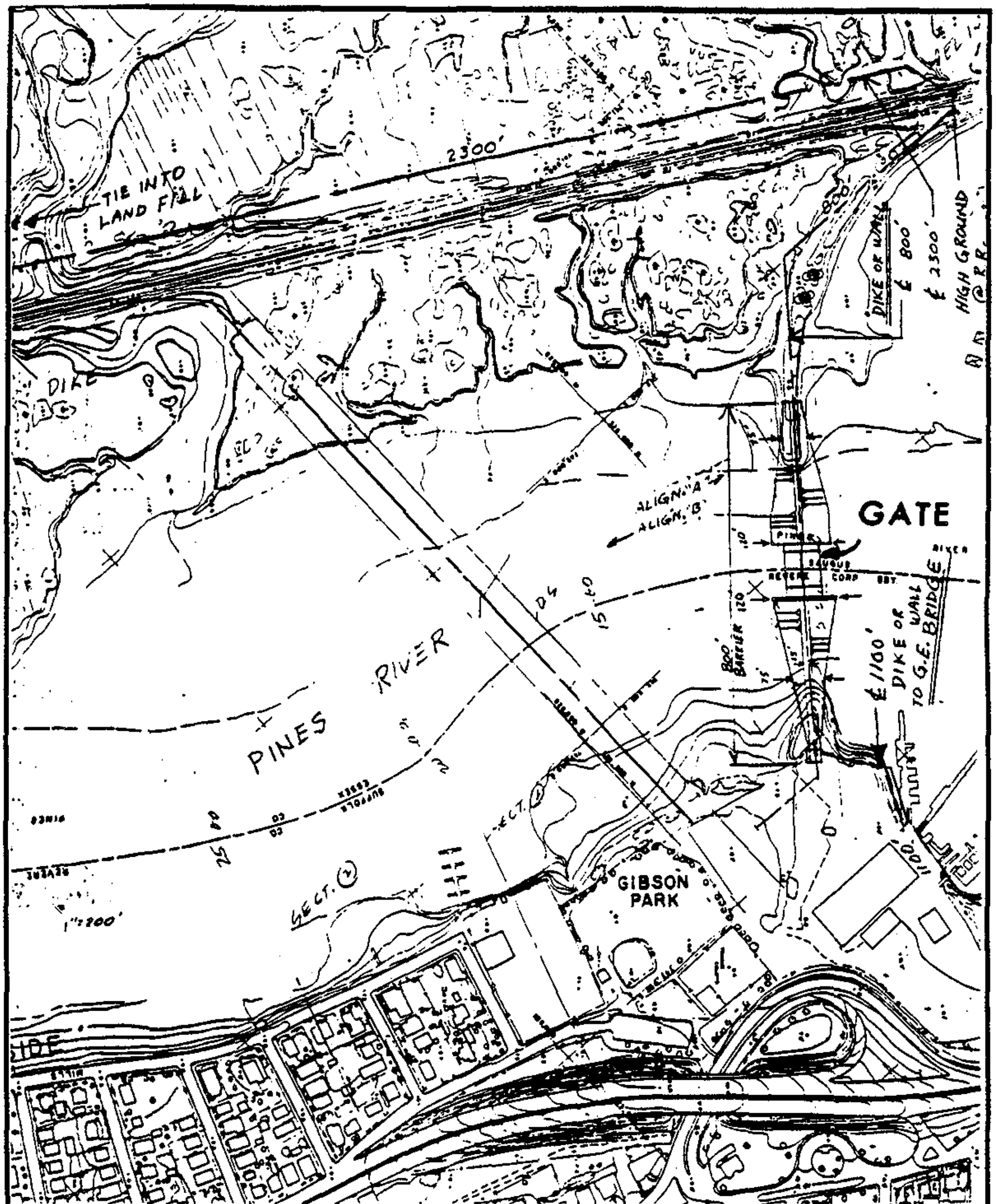
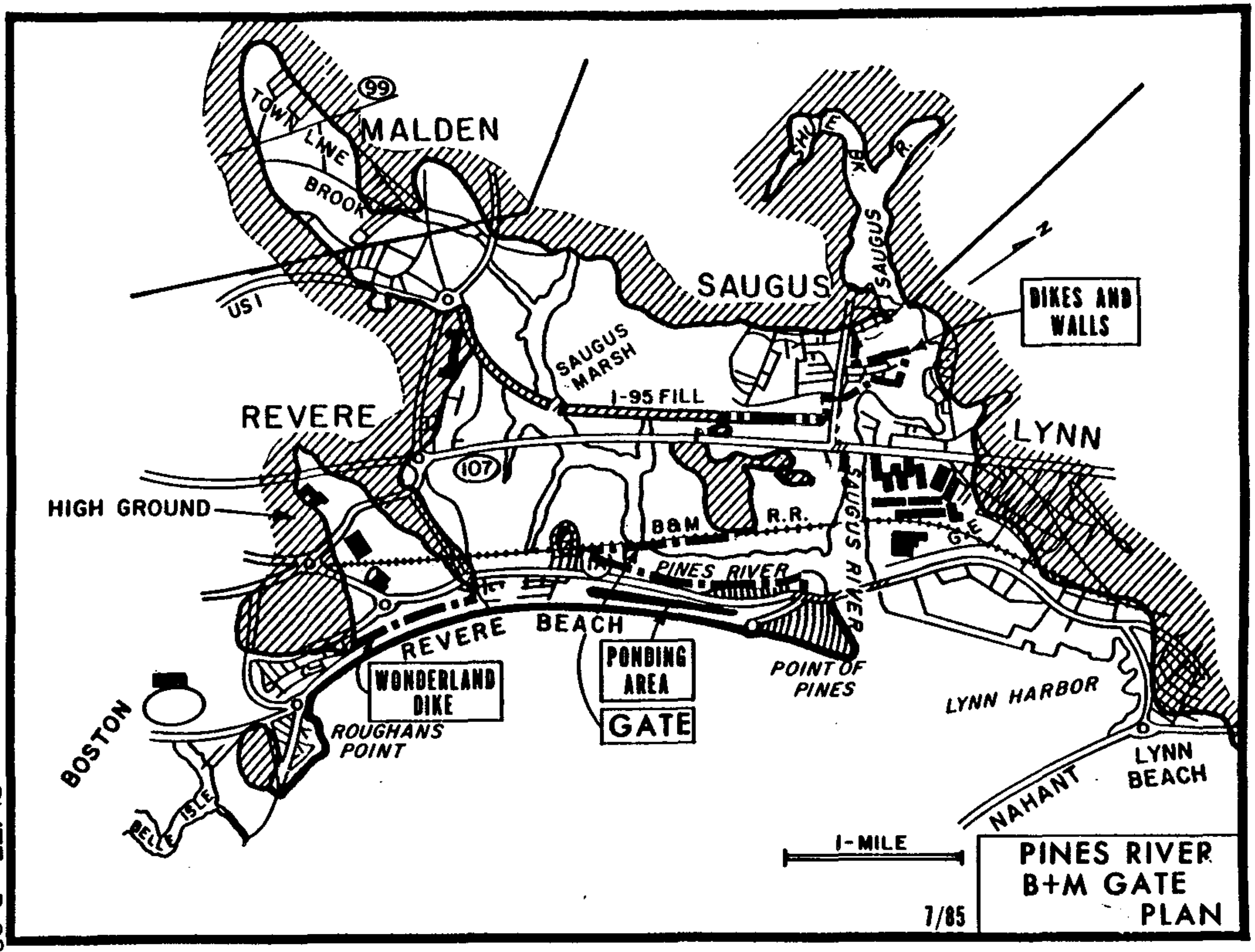

MALDEN
99
TOWN LINE BROOK
US 1
SAUGUS
SAUGUS MARSH
I-95 FILL
SAUGUS R.
DIKES AND WALLS
REVERE
LYNN
107
HIGH GROUND
B&M R.R.
1A
PINES RIVER
SAUGUS RIVER
REVERE BEACH
WONDERLAND DIKE
PONDING AREA
POINT OF PINES
GATE
LYNN HARBOR
ROUGHANS POINT
BOSTON
BELLE ISLE
WINTHROP
ATLANTIC OCEAN
1-MILE
NAHANT
LYNN BEACH
N
7/85
PINES RIVER GATE PLAN

PLATE R-20



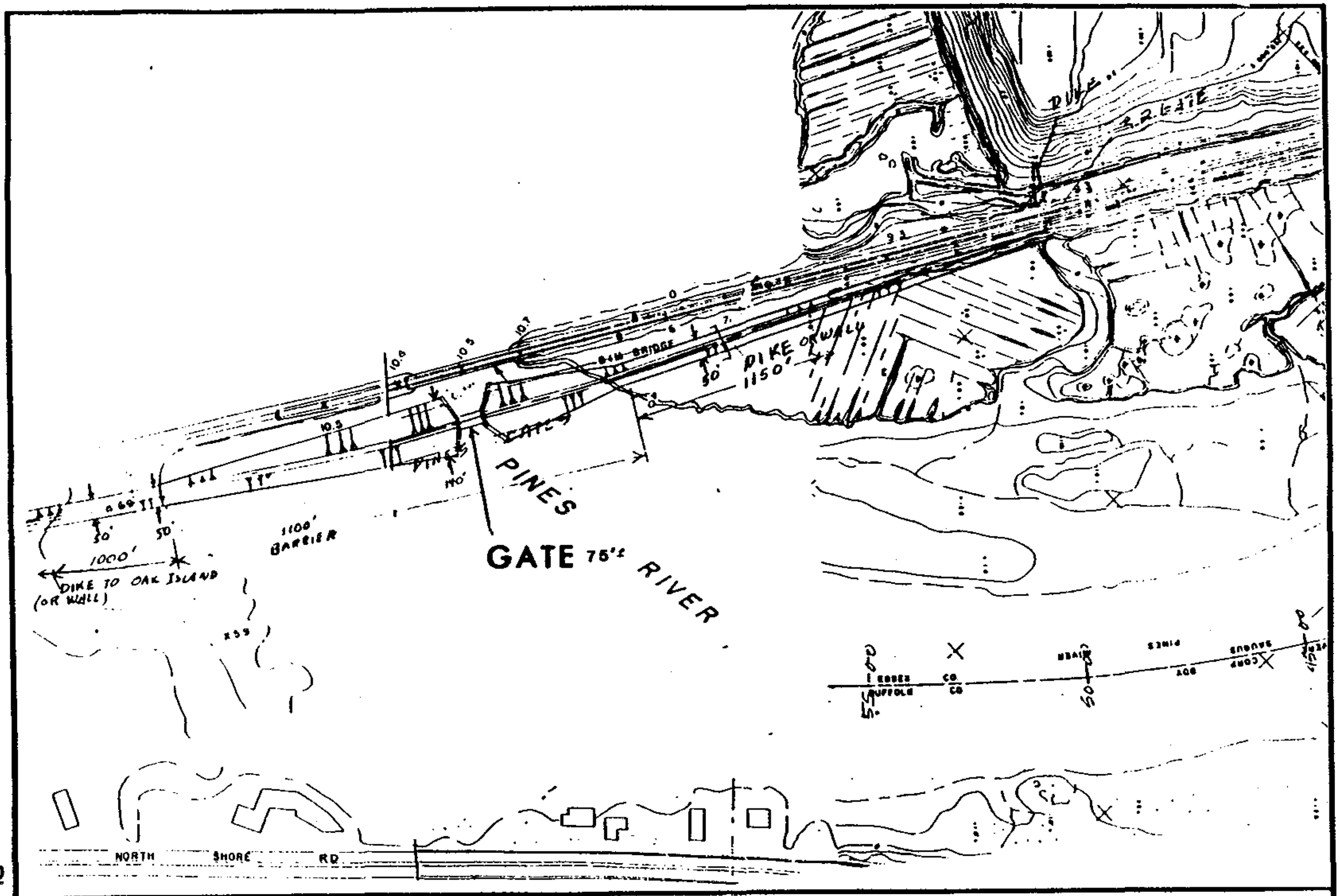
PINES RIVER GATE

PLATE R-21



MALDEN
TOWN LINE BROOK
99
US 1
REVERE
107
HIGH GROUND
SAUGUS MARSH
I-95 FILL
SAUGUS
SAUGUS
DIKES AND WALLS
LYNN
B&M R.R.
SAUGUS RIVER
PINES RIVER
REVERE BEACH
WONDERLAND DIKE
PONDING AREA
GATE
POINT OF PINES
LYNN HARBOR
ROUGHANS POINT
BOSTON
BELLE ISLE
NAHANT
LYNN BEACH
N
1-MILE
7/85
PINES RIVER
B+M GATE
PLAN

PLATE R-22



PINES RIVER
B+M GATE

PLATE R-23

Public Involvement - Following numerous meetings with public representatives and receipt of many letters voicing support for the Regional Saugus River Floodgate Plan detailed studies were initiated for several alignments at the floodgates, as well as for shorefront, hydraulic, environmental, design, costs, benefit, real estate and social investigations. Extensive public involvement followed including coordinating meetings with the Citizen Steering Committees and Technical Group members and others affected, news releases, television and radio interviews and broadcast by both the Corps and public participants. As a result interest and participation grew in the study and the committees grew with representations of additional organizations. Extensive formulation and analyses followed on the Regional Plan with the help of these participants.

Several forums were used to solicit concerns. On a project of this magnitude with a sensitive estuary potentially affected, an Environmental Impact Statement would be needed requiring a public scoping meeting and Federal Environmental review for this document which describes major concerns of the project. So as to have full benefit of the coordination of state and local agencies participation in the study and assist local sponsors, the study initiated the state's environmental review process which requires a public scoping meeting and an Environmental Impact Report. As part of the state's process, an outline of the scope of investigations was provided by the state. Both scoping meetings were held which provided an extensive list of questions and concerns. In addition the four Citizen Steering Committee's and Technical Group met on several occasions, including a field trip to similar projects, which all resulted in questions, comments and suggestions which were instrumental in scoping out and accomplishing the study. Meetings with individual property owners, organizations, legislators and a workshop with the most potentially affected (by construction features) area at Point of Pines was held.

Summary of Investigations

(a) The hydrology and water quality concerns including changes in currents, tides, flushing, salinity, sea level rise, breaching of the I-95 fill and estuary dynamics with and without tidal floodgates at the mouth of the Saugus River underwent extensive investigations. These efforts were needed to formulate a project to assure safe flows for navigation and no significant impact on the estuary as explained further in this section.

(b) The level of effort to identify the resources in the estuary and determine potential impacts was largely geared toward those areas where impacts might occur. In addition to cover typing the entire estuary to document the different areas of marsh vegetation, mud flats, rivers and so forth, the study obtained cross sections of the marsh at selected locations to determine the salinity of the soil and density of vegetation. For example, in the Saugus River just downstream of the Saugus Iron Works, more detailed surveys were accomplished since it was initially believed the project may adversely affect the high marsh. However, this was found not to be the case. Subsequent field surveys of the estuary during tide levels matching the proposed frequent gate closure levels, revealed all wetlands remained submerged at a closure elevation of 7 ft. NGVD.

The study also included surveys of birds, fish and shellfish and collection of other valuable data. The surveys were conducted to obtain information of the types and abundance of species found in the study area. Since the project from the very start determined the floodgates could be designed for no significant impact on the estuary, it was important for the hydrology and water quality studies, gate selection and project operations to assure this would be the case. With no significant change in hydrology or water quality due to the project, there would be no significant impact on the estuary dynamics. Thus the scope of environmental studies were geared to potential impacts from the footprint of the floodgates, Lynn Harbor dike, and the Point of Pines features. The physical location of these three features would define the environmental impacts and any mitigation requirements. The EIS/EIR and Environmental Appendix explains more about the environmental investigations and project impacts from the floodgate's physical location. In later sections alternatives to reduce physical impacts are discussed.

(c) The major concern that the project would induce secondary development, especially in the estuary, was contracted out for evaluation to IEP, Inc. an environmental consultant. Essentially they concluded that without the proposed project, development will continue within the 100-year floodplain as long as it is economical and the land is available. Development within the marsh is precluded by regulation, although illegal filling continues to some degree. The proposed project would not change the controlling factors outside of the marsh, which appear to be land availability and economics, and would not change the regulatory protection of the marsh itself. Therefore, it was concluded that the protection afforded against flooding by the project would not lead to any induced development within the marsh or the 100-year floodplain.

In an investigation of wetland filling, IEP estimated from a review of photographs that almost 60 acres of wetlands appeared to have been filled since 1978 (or about 6 acres per year), more detailed investigation by the Corps, however, concluded only about 0.5 acres per year had actually been filled. However, the pressures on developing the estuary definitely exist. Over about a seven month period the Corps issued seven Cease and Desist orders for activities in the wetlands. One factor would play a very significant role in curtailing continuing illegal wetland filling in the estuary if the project is built. In order to protect the storage area in the estuary for the project's design conditions, the estuary protection program described in the main report would be implemented. The emphasis and priority of protecting the estuary by the Corps, other regulatory agencies, citizens and interest groups should result in a reduction in the loss of estuarine wetlands as a result of the project.

(d) The question of where to locate the floodgate underwent extensive investigations. These investigations were nearing completion at the time the city of Revere advised the Corps that the Point of Pines local protection project could not be financed. Alignments 1 and 2 for the floodgates had depended on tieing into the Point of Pines project's wall along the Saugus River (See <u>Plate R16</u>). Alignment 2 remained the lowest cost alignment even after Point of Pines feature were added to the Regional Plan for both alignments 1 and 2. The economic feasibility of the Regional Plan significantly improved with the addition of Point of Pines which offered substantial benefits to the project at a lower increase in cost. The Regional Plan at alignment #2 benefits the Point of Pines project by reducing the length of wall by 1000 feet needed along the river side and provides the residents some additional reduction in damages. More important it offers the residents another opportunity to receive protection through the funding of the Regional Plan.

The possibility of tieing Alignments 1 and 2 directly to the bridge approach via a wall along the Saugus River, rather than requiring Point of Pines' entire shorefront be improved was discarded. This scheme would not have reduced the overtopping of the shorefront but would have blocked off the drainage path overtopping water needed to get out to the river. Consequently flooding would have been made worse at Point of Pines under severe storm conditions.

The problems with locating the floodgates adjacent to the bridge or west of the bridge are explained later. Significant additional impacts and costs result from Alignments 3,4 and 5, which do not protect Point of Pines.

(e) Concerns for impact on fisheries using numerous small 10'x10' gates was substantially alleviated when larger 14'x50' gates were found to be more cost effective. During final design and model studies, more detailed investigations may find that even larger tainter gates, with sills a few feet lower and top opening a few feet higher may be even more efficient As shown in the following section, the number of gates and flushing area selected represents a worse case condition to meet the navigation criteria. If conditions prove to be less severe, then decisions will need to be made whether to (1) reduce the flow area, by say 10 to 20%, (2) leave it at its present recommended opening, or (3) increase the area by raising the top of gates, as requested by the US Fish and Wildlife Service. At any case there should not be a significant change (plus or minus 20%) in the number of gates or flow area.

(f) The concerns for impacts on siltation in the vicinity of the floodgates will largely be addressed during design with model studies. Siltation in the estuary is addressed in the Water Quality Appendix and no significant siltation is expected as a result of the project since there would be little change in estuary currents. Adjacent to the floodgates within 500 feet upstream and downstream there would be a change in siltation and erosion, although its not expected to be significant. The river bottom will be dredged in order to channel water through the gates. Model studies in design will evaluate the currents and their affect on the river bottom and siltation to reduce the impact.

<u>Plan Description</u> - The following summarizes major features of the Regional Plan, and a more detailed description of each feature will follow.

Major features include:

. a floodgate structure across the mouth of the Saugus River which would prevent tidal surges up the Saugus and Pines Rivers. The gates would be designed to maintain both safe navigation and the natural flushing and tide levels of the marsh and rivers. The floodgate structure would be located either upstream or downstream of the General Edwards Bridge;

. the structure would include at least a 100 foot wide navigation opening similar in width to the existing navigation opening under the General Edwards Bridge. Additional flushing gates would be required on either side of the navigation gate to meet the navigation and estuary criteria;

. along the Lynn Harbor shoreline, about 8900 feet of dikes and walls would be needed to reduce overtopping which floods Lynn and flows to the estuary ;

. behind the Revere Beach seawall, in the vicinity of the Metropolitan District Commission (MDC) police station, 3,400 feet of vacant land would be raised and developed into a dike and graded toward the Boulevard for drainage. The area would also be used as a parkland. It would prevent tides which overtop the seawall from reaching developed areas and the estuary;

. a ponding area located behind the north end of Revere Beach would be protected to store tidewaters overtopping the shorefront for most storms, and a 500 foot long wall to contain the water in the ponding area and direct excess water to the estuary;

. continued maintenance of the existing seawalls and beach along Revere Beach would prevent increased overtopping along the reservation and flooding behind Revere Beach and into the estuary;

. improved enforcement and monitoring of the existing wetland regulations and modified floodplain regulations would protect the needed flood water storage in the estuary area during coastal storms accompanied by runoff from the watershed and tides overtopping various locations along the shorefront; and

. for Floodgate Alignments #1 and 2, the Point of Pines' dunes would need to be restored and protected and backed up by a Revetment. An improved wall is also needed along the river to the floodgates, as the existing wall is unstable with an exposed foundation. Revetments along the shorefront from Carey Circle to the dunes are needed to (1) prevent damages at Point of Pines, and (2) prevent failure of the existing shorefront to the point of allowing the free flow of the ocean from circumventing the floodgates and entering the estuary and storage area which would jeopardize the integrity and protection offered by the Regional Plan. Design criteria for the dunes have assumed the dunes could be breached for tides exceeding EL. 10.3 - the 1978 or 100 year event. Over the project life this tide elevation could recur on a 17 year frequency with the historical rate of sea level rise. Until design model studies of beach and dune erosion is accomplished to prove otherwise, the revetment is needed.

The following areas would benefit from reduction in coastal flooding from the plan.

Revere Beach Backshore, Revere
City of Lynn
Northgate, Revere
Town Line Brook, Revere and Malden
East Saugus, Saugus
Upper Saugus River and Shute Brook, Saugus
Point of Pines, Revere (for downstream floodgate alignments 1 and 2)
Routes 107, 1, 1A, MBTA, and B&M Railroads

FLOODGATE OPENINGS - Preliminary studies had shown that meeting the navigation criteria of not exceeding 3 knots of current or 5.1 feet per second in the navigation channel for designing the gates should yield no significant changes in tide levels or flushing volumes in the estuary. The navigation criteria was provided from prior studies by the Corps Waterways Experiment Station. In order to effectively estimate the currents more information was needed on the volumes of water that were flushing in and out of the estuary. To obtain these volume measurements, the Sewall Company in Old Town, Maine was contracted to fly and photograph the estuary on four different tide conditions while the Corps measured the various tide levels around the estuary during the flight. Color infrared aerial photography was taken and the water surfaces planimetered by Sewall. From this information and other aerial photographs and maps, the volume of water was estimated at various tide levels.

To calibrate and check the volume of water flowing and estimated currents during various tidal ranges, current measurements were also taken between each pier of the General Edwards Bridge on a high spring tide over a full tide cycle. The results provided information to calibrate models to estimate what the currents and flushing volumes would be and corresponding tide levels in the estuary for various gate designs.

Three tidal ranges were investigated for several gated openings. The three tide ranges were:

(1) the Mean Tidal Range which represents the average of all tidal ranges and measures 9.5 feet from Mean High Tide (El 5.0 ft NGVD) to Mean Low Tide (El.-4.5). Currents experienced during this range are equalled or exceeded during 50% of tides.

(2) The Mean Spring Range is an 11 foot change in tides from Mean Spring High Water (El 5.8) to Mean Spring Low Water (El -5.2). Conditions equal or exceed this tidal range during 20% of all tides.

(3) the Maximum Astronomic Range is a 14.6 foot change in tides ranging from the Maximum Predicted Astronomical High Water (El 7.5) to Minimum Predicted Astronomical Low Water (El -7.1). Conditions equal or exceed this tidal range on about 0.01 percent of tides which is less than once a year.

CURRENT AND TIDAL RANGE

	Change in Tide (feet)	Current & Tide Range Equal or Exceeded (% of Tides)
Mean Tidal Range	9.5'	50%
Mean Spring Range	11.0'	20%
Maximum Astronomic Range	14.6'	0.01%

This information is later used to show the percent of tides when safe flows for navigation are exceeded for various gate design openings. With each higher range in tides larger volumes of water pass out of or into the estuary through the floodgates. The fastest current occurs for only about half an hour around the peak flow which occurs at about mid tide or EL.0.0 ft. NGVD. In order to achieve maximum efficiency of the tide gates at peak flow, the gates were positioned so they were totally submerged during this peak flow period. The top of the flushing gates were placed at El 0.0 to make maximum use of their flow area. Information will be explained later on how the flushing gate sizes were selected and the bottom of their openings. The navigation gate sill was relocated on the bottom of the channel in order to allow normal minimum tide levels to occur in the estuary. This location also helps to meet the navigation current criteria.

Gate Flows for Existing Conditions - Several schemes were developed to evaluate the area of openings needed in the floodgate structure to meet the navigation and estuary criteria. Initially, the navigation criteria was applied to existing tidal conditions. Table 13 shows six gated flow schemes and average maximum currents through their gates ranging from 1.3 to 14.1 feet per second. Gate scheme N3 was initially selected with a maximum flow of 5.3 fps and presented to the Steering Committees.

Although representatives of the commercial fishing fleet and the recreation fleet indicated they would have no problem with this 5.3 fps current, Scheme N3 would increase the currents experienced in the river. Navigation interests opposed any increase in currents and reported several problems with the existing currents at the mouth of the river:

- small vessels navigating the swift currents are forced sideways into other vessels or bridge abutments;

- vessels attempting to cut across currents have problems mooring at the Point of Pines Yacht Club;

- there is a safety problem due to the swift currents which make it difficult for victims and rescuers when people fall off the docks and boats near the Point of Pines Yacht Club.

- wakes from boats disturb or damage nearby moored vessels.

The river is posted for navigation at 5 miles per hour (or 4.3 knots) near the General Edwards Bridge. Most agree a 3 knot (5.1 fps) current should not cause a problem to navigation since the reported capability of lobster boats is 8 to 10 knots and sail boats is 5 to 6 knots. General Electric fuel barges are able to reach about 9 knots.

Mariners did report problems with swift and erratic currents and eddy's near the bridge. Localized currents have scoured out between the piers of the bridge. The MDC on several occasions replaced rock around the bridge piers to reduce erosion at the piers.

TABLE 13

ALTERNATIVE OPENINGS FOR GATES AND EXISTING VELOCITIES

	GATE SCHEME					
	FC	N1	N2	N3	N4	EN
Open Area below EL. 0.0 ft.NGVD (Square Feet)						
	1260	2800	3500	5200	8700	12,170
Maximum Average Velocity (ft. per sec.):						
Mean Tide Range (50% of Tides)	9.4	5.2	4.2	2.9	1.7	1.3
Mean Spring Tide Range (20%)	10.8	6.1	5.0	3.4	2.1	1.6
Maximum Astronomic Range (0.01%)	14.1	8.8	7.3	5.3	3.3	2.4

Gate Flow for Future Conditions - Other consideration in the design of the gated openings were future conditions. Over the life of the project relative sea level is expected to rise at least one foot based on the historical rate of rise and maybe higher. The rise in sea level will result in an increase of at least 10 percent in the volume of salt water flushing in and out of the estuary.

Also there is an environmental interest to breach the I-95 embankment which if accomplished by others in addition to the dredging of the Saugus and Pines Rivers would increase flushing an additional 10 percent.

During the study, however, it became apparent that the I-95 would not likely be breached by others due to potential impacts on flooding at East Saugus. The I-95 currently provides a one to two foot reduction in tide levels for frequent coastal storms. Making holes through the fill or total removal would allow tides to rise in East Saugus. It is assumed the I-95 would not be breached due to East Saugus strong opposition.

There are several issues which should be considered before others consider breaching the I-95 fill among them are increased flooding levels at East Saugus, increased flushing in the estuary resulting in increased currents at the mouth of the river and faster currents in rivers. Further studies by others would need to be undertaken to assess these concerns. A cursory review of aerial photographs before the I-95 fill was built (about 1968) and recent aerial photography did not show a significant difference in vegetation in the affected area. The environmental values of breaching the fill should also be considered by others before it is considered.

To prevent the gates from causing problems to mariners from either increased currents now or in the future the criteria was modified.

Floodgate Criteria - Refinement of the criteria for designing the gated openings was to design the gates so there would be no significant change to currents at the mouth of the river to the point the gates would become the controlling restrictions in the future, or cause problems to navigation, or no significant change to the flushing and tide levels in the estuary.

Sizing of Gated Openings - To achieve the criteria for sizing the openings, the existing cross sections of the river mouth were determined: The flow area of the river is most critical at the point the currents reach their maximum velocity of flow - that is at about mid tide about EL. 0 ft. NGVD, or EL. 4.6 ft. MLW.

The cross sectional areas for Alignments 2,3,4 and 5 provided nearly the widest range at the mouth of the river in flow area at mid tide, which are:

Alignment 2	8700 square feet
Alignments 3 and 4 or under the bridge -	12,170 square feet
Alignment 5	8200 square feet

The potential flow area is not the only consideration in determining the highest velocity rates, the efficiency and obstruction to flow are also important. For planning purposes rather than selecting 8200 SF, the minimum flow area, the 8700 square feet was selected to reasonably represent the open area needed in the gates, so as not to significantly change the existing restrictive control of the river.

More refined analysis would be accomplished during detailed engineering in evaluating currents in the river and through various types and openings in its gates.

The maximum average velocity of currents through the 8700 SF (Scheme N4) of gated openings would be less than 5.1 fps (3k) even with one foot of sea level rise, breaching of the I-95 fill and dredging of the rivers.

Although 8700 SF may not significantly change the flow in the river, it may not be the optimum or most economically efficient flow area in meeting the criteria. A sensitivity analysis of flow areas to meet the criteria is required.

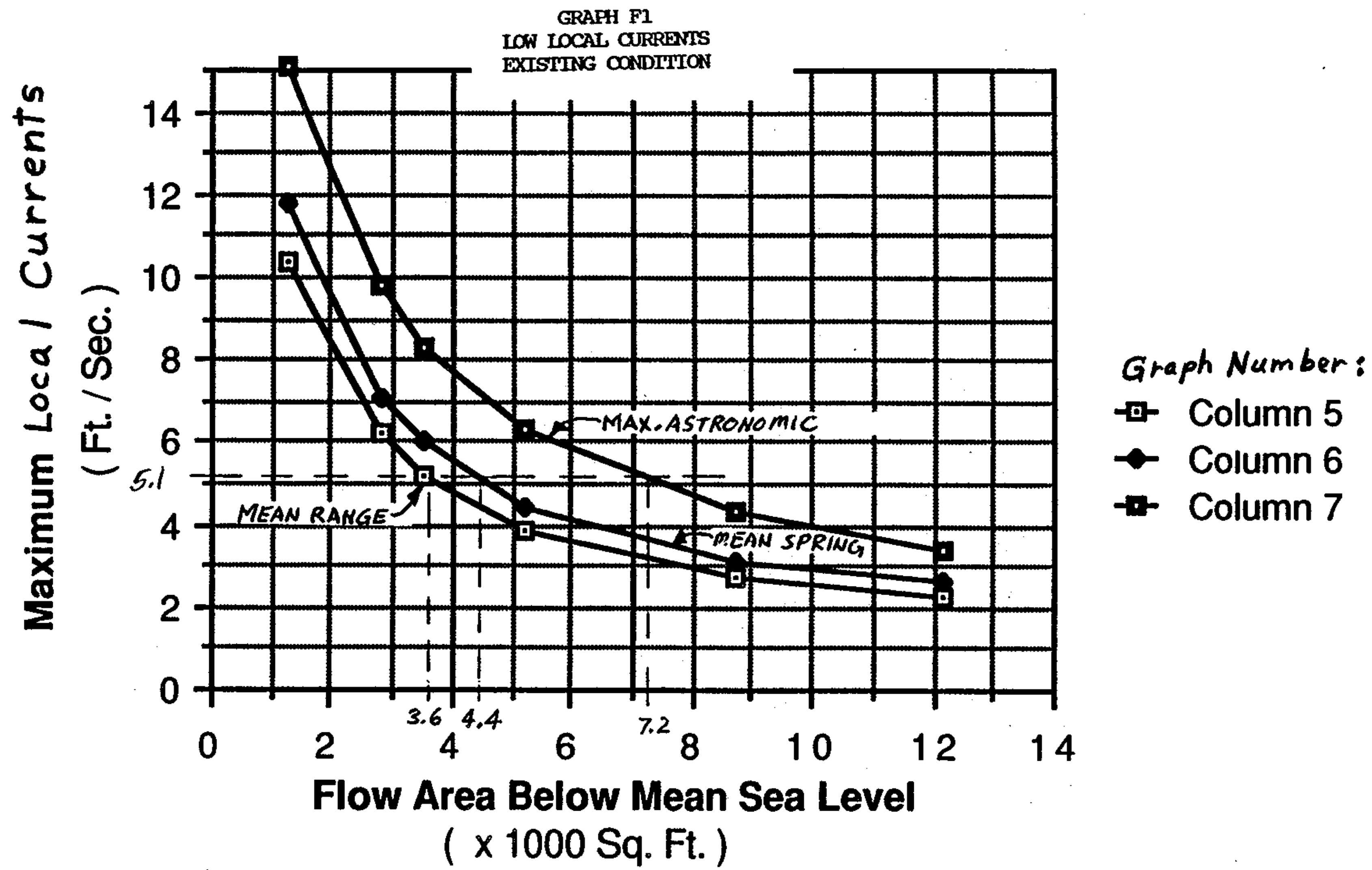
Sensitivity of Gated Flow Area - It is important to determine how sensitive the gated flow area is to the local currents in meeting the navigation criteria of not to exceed 3 knots or 5.1 feet per second. Then also determine whether the environmental criteria is sensitive to the gated flow area optimized to meet the navigation criteria. The magnitude of the currents is not the only important consideration but also the direction of currents. Modeling in design will determine if dangerous cross currents or eddies would exist and what project modifications are needed to assure safe navigation. The criteria should not be significantly exceeded for existing conditions or future conditions with the probable historic rate of sea level rise. The actual historic rate of 0.8 feet in 100 years will be used in this analysis. Due to entrance and exit losses and the friction of the water passing through the gates and the channels leading to the gates, current velocities will vary across the width of a gate and slightly from gate to gate. The highest expected current or local current in a gate will generally be one to two feet per second (FPS) faster than the average current. Only the average currents have been considered thus far since this is all the modelling could handle in designing the gates at this time due to budget and time constraints. More sophisticated modelling in design will include local current evaluation. The analysis which follows shows first the point at which a gated flow area exceeds the navigation criteria for each of the three tidal ranges; (Mean Range, Mean Spring Range and Maximum Astronomic Range) and keeping in mind that the percent of tides equalled or exceeded for each range is 50%, 20% and 0.01%. This analysis is done for both a local current 1 FPS faster and 2 FPS faster than the average maximum current developed by the planning model. Tables F1 and F2 show the addition of "plus 1 FPS" and "plus and 2 FPS," respectively, to the maximum average currents, previously reported for each gate scheme and tidal range. Graphs F1 and F2 plot this data. The graphs show that under "existing conditions" the navigation criteria (5.1 FPS) is reached for the following gated flow areas:

Flow Area When Navigation Criteria Is Reached For Local Currents

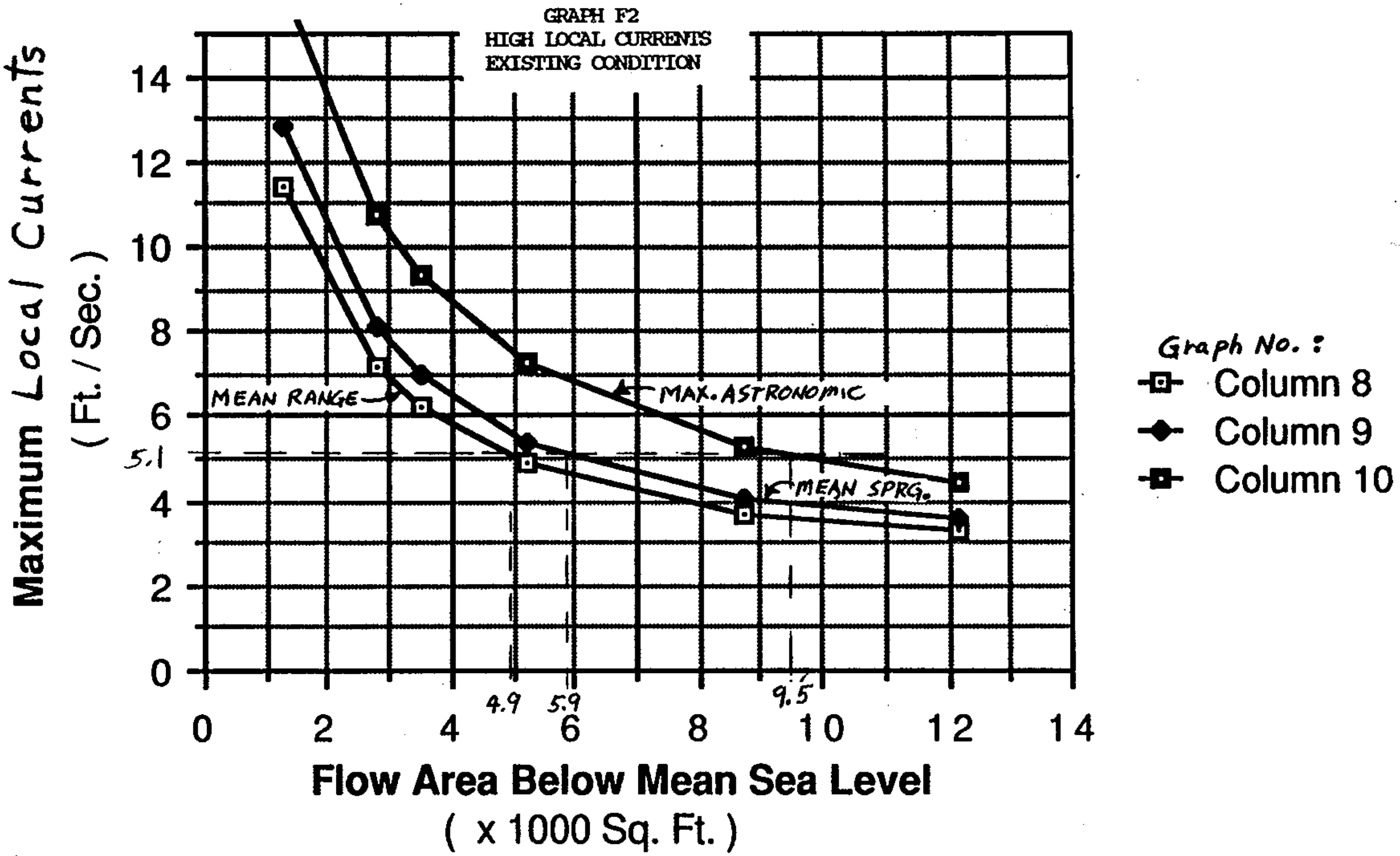
	Low level Plus 1 FPS	High level Plus 2 FPS
Mean Range (50%)	3600 SF	4900 SF
Mean Spring (20%)	4400 SF	5900 SF
Max Astron (0.01%)	7200 SF	9500 SF

This means that to prevent currents from exceeding the navigation criteria (even on 0.01% of tides) during the Maximum Astronomic Range the gated flow area should range from 7200 SF to 9500 SF depending on whether local currents are 1FPS (low level) or 2FPS (high level) faster than the maximum average current under "existing conditions".

The same analysis was accomplished for a future condition of 0.8 foot of sea level rise at the historical rate. For the three tidal ranges, the tidal prism in the estuary or its flushing volume will change as follows:



GRAPH F1
LOW LOCAL CURRENTS
EXISTING CONDITION
Maximum Local Currents
(Ft. / Sec.)
Flow Area Below Mean Sea Level
(x 1000 Sq. Ft.)
MAX. ASTRONOMIC
MEAN RANGE
MEAN SPRING
5.1
3.6
4.4
7.2
0
2
4
6
8
10
12
14
Graph Number:
Column 5
Column 6
Column 7


GRAPH F2
HIGH LOCAL CURRENTS
EXISTING CONDITION
Maximum Local Currents
(Ft. / Sec.)
Flow Area Below Mean Sea Level
(x 1000 Sq. Ft.)
MEAN RANGE
MAX. ASTRONOMIC
MEAN SPRG.
5.1
4.9
5.9
9.5
Graph No. :
Column 8
Column 9
Column 10
0
2
4
6
8
10
12
14

	Change in Tidal Prism w/0.8' Sea Level Rise
Mean Range	+9%
Mean Spring Range	+12%
Maximum Astronomic Range	-2%

Although the change in currents were not specifically determined, the currents would change similar to the change in the tidal prism.

The Maximum Astronomic Range shows a reduction in the tidal prism since to prevent damage at Elevation 8 ft NGVD, the water level in the estuary is truncated at El 7.5 to 8, when in Broad Sound the Maximum height would have reached 8.3 ft NGVD. With the closing of the gates for Maximum Astronomic levels, there would be about a 2 percent reduction in flushing volume for 0.01% of tides and a corresponding small reduction in currents.

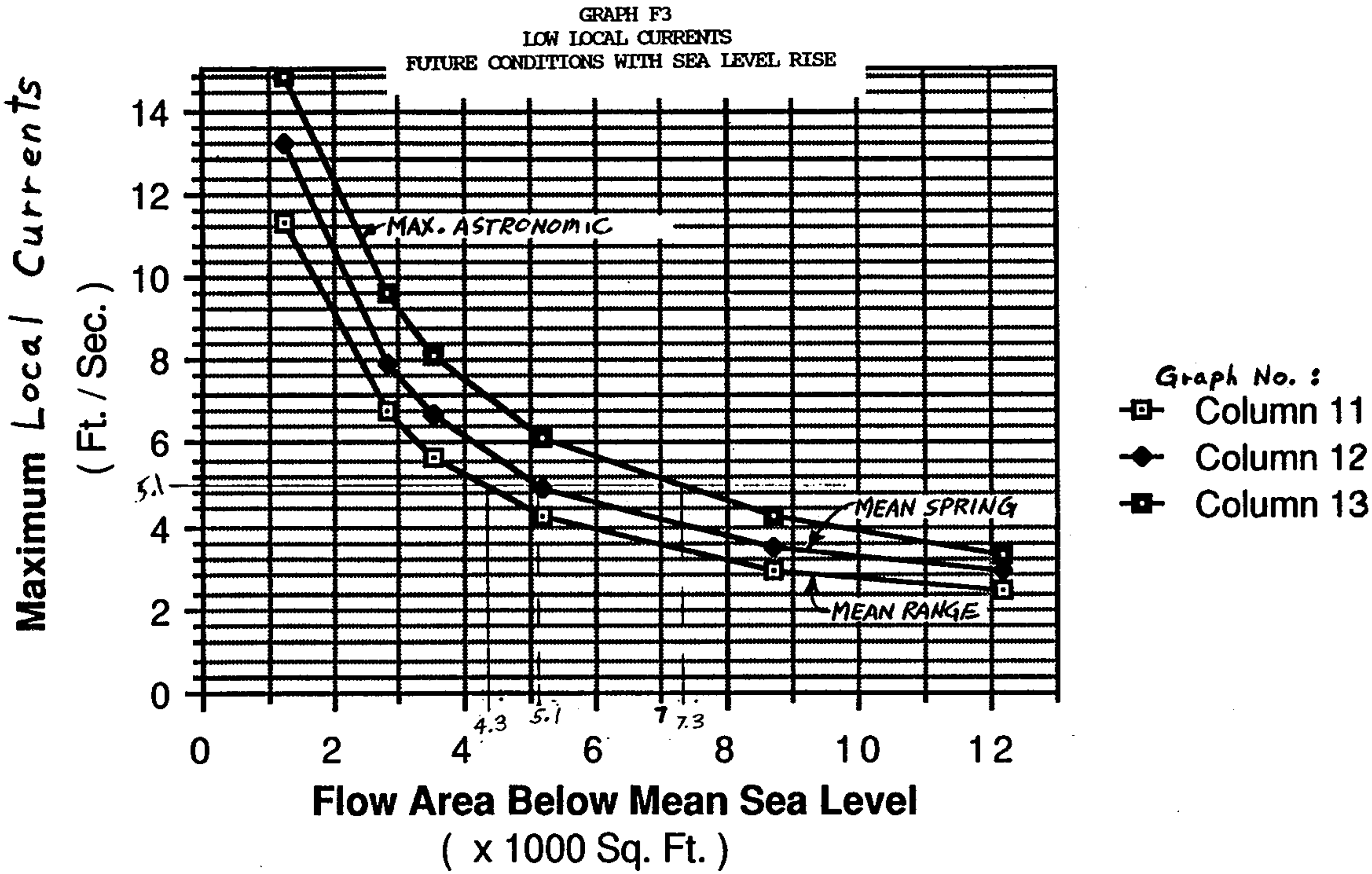
Tables F3 and F4 show these changes (+9%, +12%, -2%) from the existing condition currents in Tables F1 and F2. Graphs F3 and F4 plot the results in Tables F3 and F4 which show that with future sea level rise the navigation criteria (5.1 fps) is exceeded for the following gated flow areas:

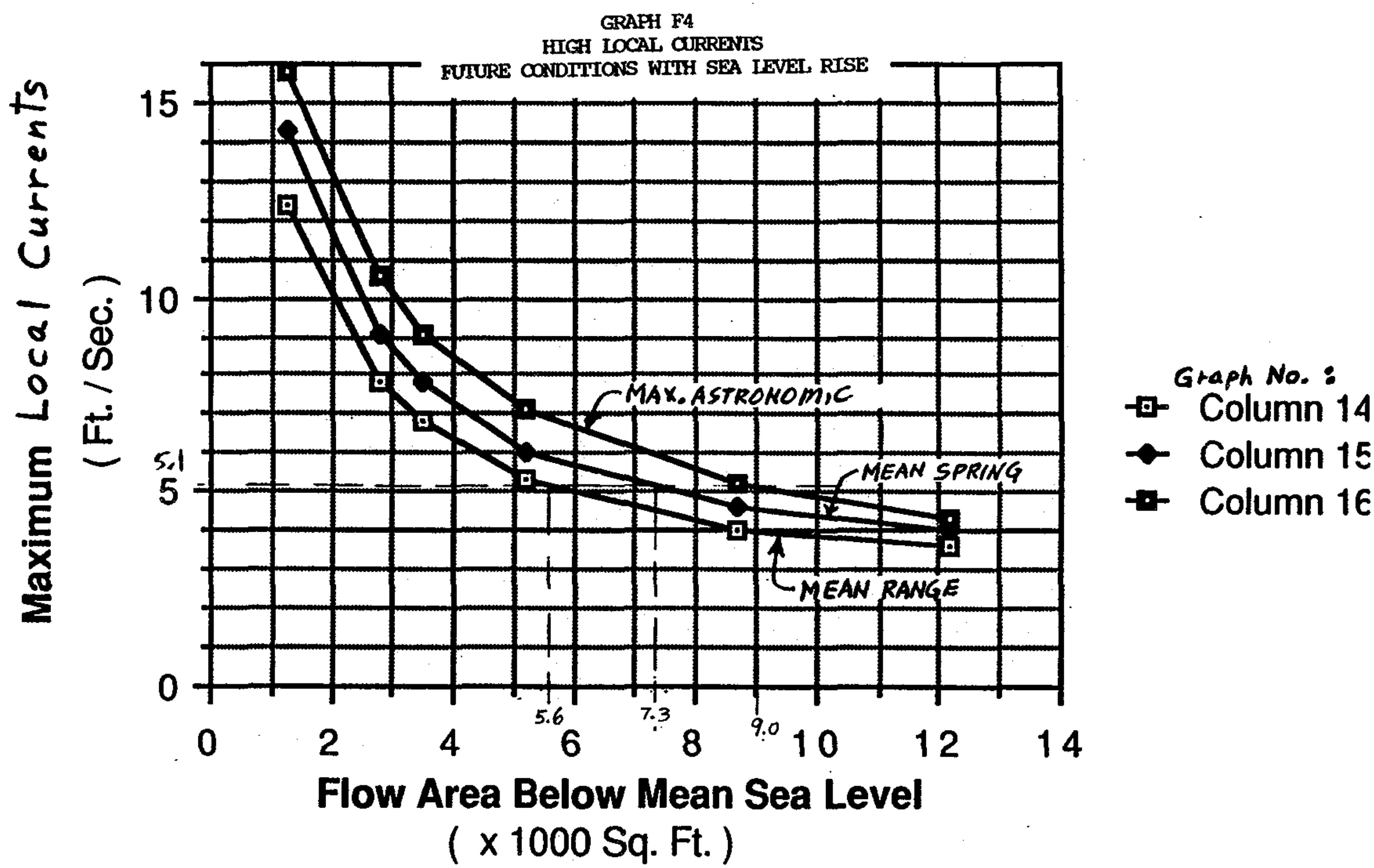
	Future With Sea Level Rise and for Local Currents at	
	Low Level Plus 1 FPS	High Level Plus 2 FPS
Mean Range (50%)	4300 SF	5600 SF
Mean Spring Range (20%)	5100 SF	7300 SF
Maximum Astronomic Range (0.01%)	7300 SF	9000 SF

Again this means that to prevent currents from exceeding the navigation criteria (even on 0.01% of tides) for the Maximum Astronomic Range with sea level rise the gated flow area should range from 7300 SF to 9000 SF depending on whether local currents are 1 FPS to 2 FPS faster than the maximum average current.

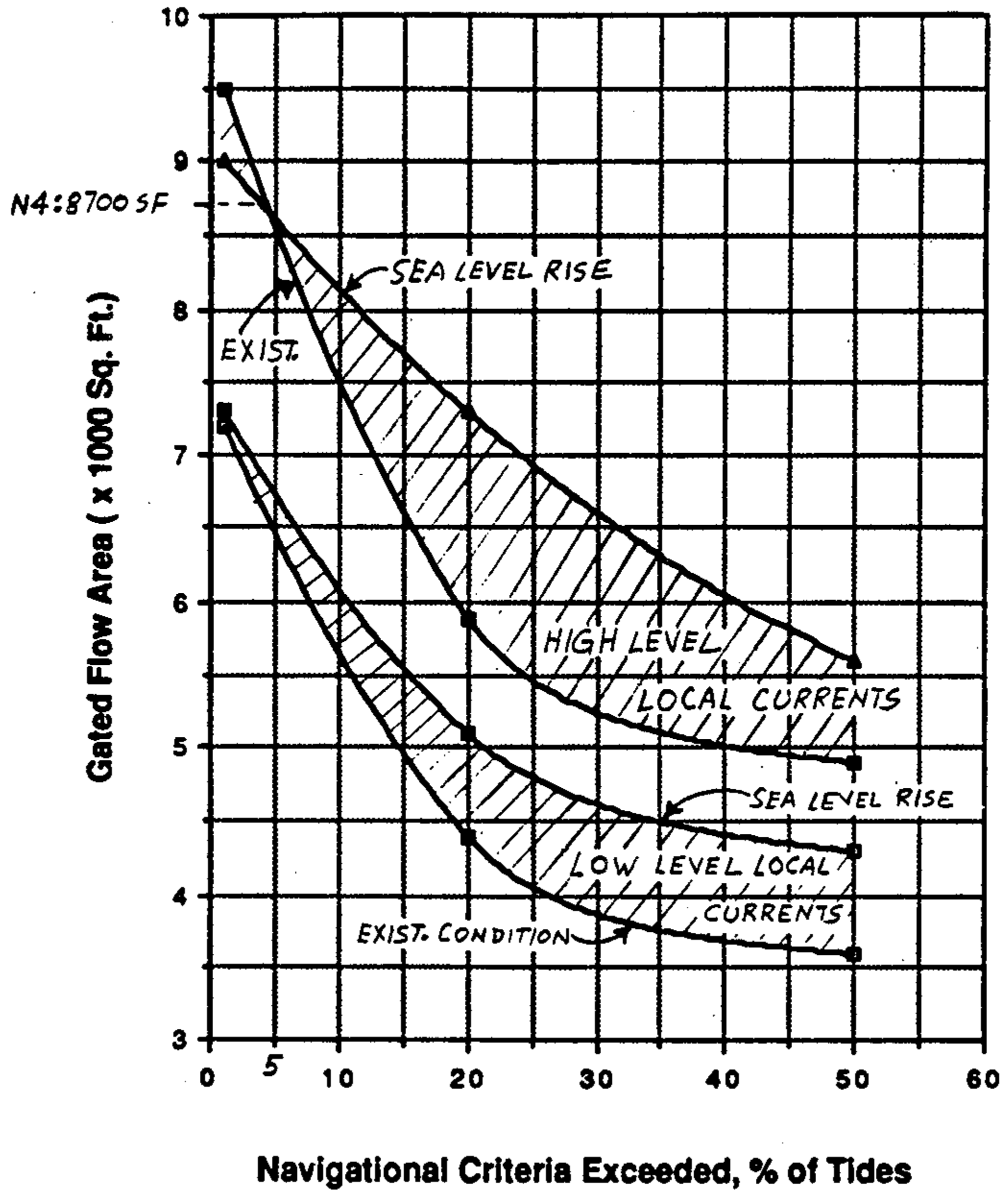
The next step is to plot these results on Graph F5 to show the Percent of Tides when the navigation criteria is exceeded by each flow area. As shown on the graph, the N4 gated flow area of 8700 SF would exceed the navigation criteria on less than 5 percent of tides *if* the High Level of 2 FPS increase in the maximum average current is realized. This is true for both existing conditions and sea level rise. If however, the increase for local currents is only 1 FPS the low level would apply and about 7300 SF of flow area would be needed.

For planning purposes and so as not to significantly underestimate the needed flow area and project cost, the N4 gate scheme with 8700 SF of flow area should be used to reasonably represent gated flow requirements and project costs.


GRAPH F3
LOW LOCAL CURRENTS
FUTURE CONDITIONS WITH SEA LEVEL RISE
Maximum Local Currents
(Ft. / Sec.)
14
12
10
8
6
5.1
4
2
0
MAX. ASTRONOMIC
MEAN SPRING
MEAN RANGE
4.3
5.1
7
7.3
0
2
4
6
8
10
12
Flow Area Below Mean Sea Level
(x 1000 Sq. Ft.)
Graph No.:
Column 11
Column 12
Column 13


GRAPH F4
HIGH LOCAL CURRENTS
FUTURE CONDITIONS WITH SEA LEVEL RISE
Maximum Local Currents
(Ft. / Sec.)
Flow Area Below Mean Sea Level
(x 1000 Sq. Ft.)
MAX. ASTRONOMIC
MEAN SPRING
MEAN RANGE
5.1
5.6
7.3
9.0
0
2
4
6
8
10
12
14
5
10
15
Graph No. :
Column 14
Column 15
Column 16

GRAPH F5
FLOW AREA vs. NAVIGATION CRITERIA



During final design of the project the flow area eventually selected will definitely provide safe flow for navigation. The design will also consider requests by others to raise the top of gates and reduce eddys and friction through the gates for improved fisheries passage. As explained in a following section on "Flushing Gate Selection", the preliminary optimum size of the selected flushing gate opening is 14 foot by 50 foot with a flow area of 700 SF. The navigation gate opening at mid tide (El. 0.0) or at peak flow is 1800 SF. The remaining flow area of 8700 SF less 1800 SF leaves 6900 SF for flushing gates. Ten flushing gates with 7000 SF plus 1800 SF for the navigation gate would total 8800 SF, which would satisfy the flow area selected of 8700. Graph F6 plots the number of flushing gates versus the percent of tides when each number of gates would exceed the navigation criteria. Again, the N4 scheme with 10 flushing gates would exceed the criteria on less than 5 percent of tides. If the size of gates remain the same during design, the number of gates ultimately recommended may range from 8 to 11 depending on many factors including for example local flows, sea level rise, fisheries passage, eddys and sedimentation. Graph F7 shows that 8 or 10 gates would reduce flushing in the estuary about 1 or 0.1 percent, respectively.

TABLE F1

GATED LOCAL CURRENTS - LOW LEVEL
EXISTING CONDITIONS (MAX. AVERAGE CURRENTS PLUS 1 FPS)

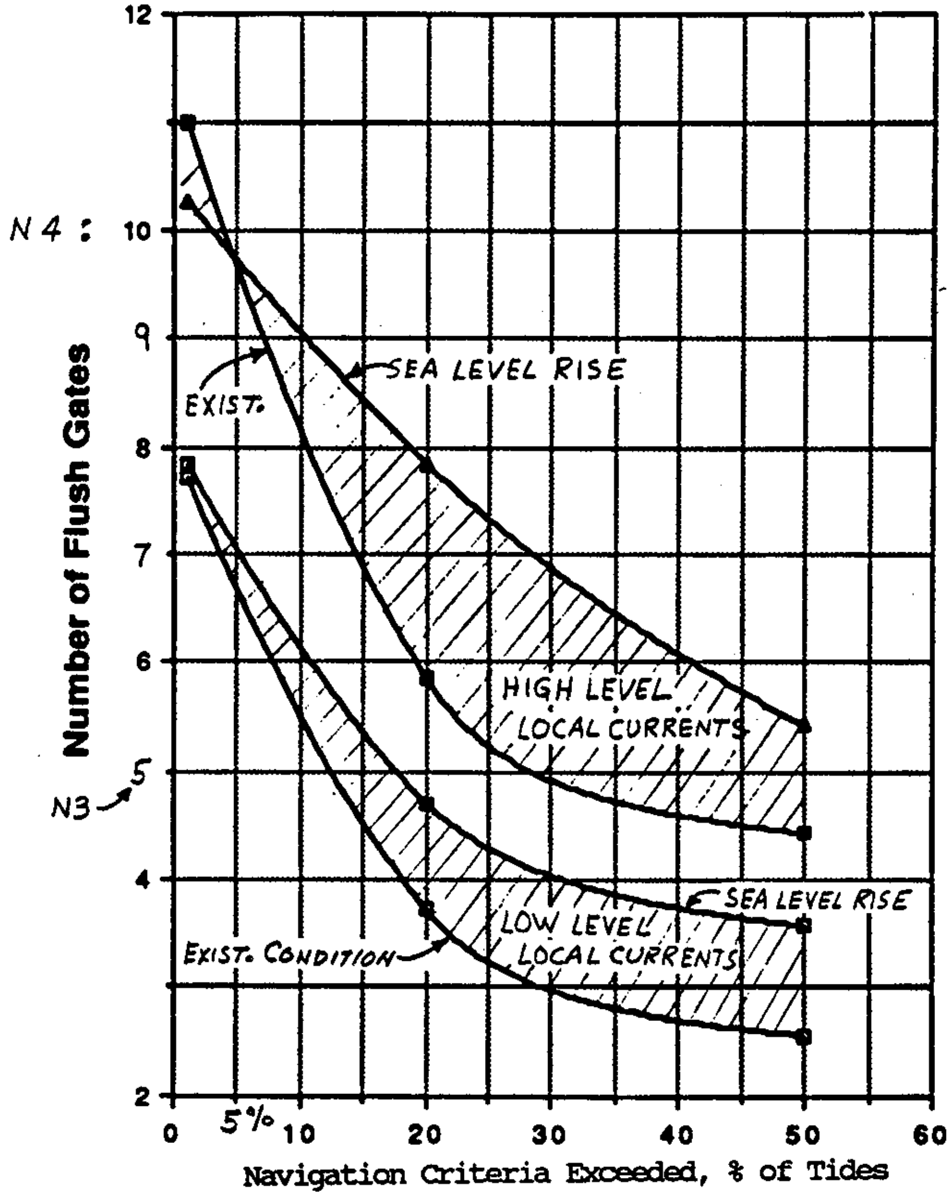
Gate Scheme	Flow Area (SF)	Graph Number and Tidal Range 5 Mean Range +1	 6 Mean Spr. +1	 7 Astron. +1
FC	1260	10.4 FPS	11.8 FPS	15.1 FPS
N1	2800	6.2	7.1	9.8
N2	3500	5.2	6.0	8.3
N3	5200	3.9	4.4	6.3
N4	8700	2.7	3.1	4.3
EN	12170	2.3	2.6	3.4

TABLE F2

GATED LOCAL CURRENTS - HIGH LEVEL
EXISTING CONDITIONS (MAX.AVERAGE CURRENTS PLUS 2 FPS)

Gate Scheme	Flow Area (SF)	Graph Number and Tidal Range 8 Mean Range +2	 9 Mean Spr. +2	 10 Astron. +2
FC	1260	11.4 FPS	12.8 FPS	16.1 FPS
N1	2800	7.2	8.1	10.8
N2	3500	6.2	7.0	9.3
N3	5200	4.9	5.4	7.3
N4	8700	3.7	4.1	5.3
EN	12170	3.3	3.6	4.4

GRAPH F6
NO. OF GATES vs. NAVIGATION CRITERIA



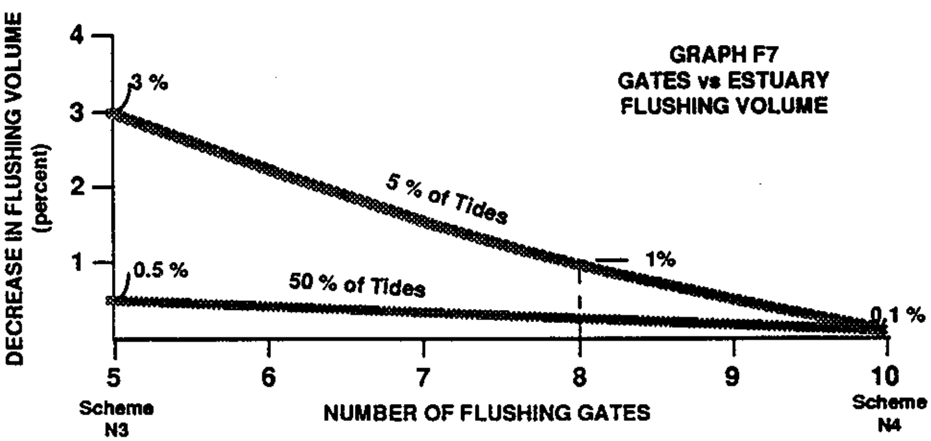


TABLE F3

GATED LOCAL CURRENTS - LOW LEVEL
WITH 0.8 FT SEA LEVEL RISE

Gate Scheme	Flow Area (SF)	Gate Local Currents (FPS) Graph Number and Tidal Range 11 Mean Range +1 (+9%)	12 Mean Spr. +1 (+12%)	13 Astron. +1 (-2%)
FC	1260	11.3 FPS	13.2 FPS	14.8 FPS
N1	2800	6.8	7.9	9.6
N2	3500	5.7	6.7	8.1
N3	5200	4.2	4.9	6.1
N4	8700	2.9	3.5	4.2
EN	12170	2.5	2.9	3.3

TABLE F4

GATED LOCAL CURRENTS - HIGH LEVEL
WITH 0.8 FT. SEA LEVEL RISE

Gate Scheme	Flow Area (SF)	Gate Local Currents (FPS) Graph Number and Tidal Range 14 Mean Range +2 (+9%)	15 Mean Spr. +2 (+12%)	16 Astron. +2 (-2%)
FC	1260	12.4 FPS	14.3 FPS	15.8 FPS
N1	2800	7.8	9.1	10.6
N2	3500	6.8	7.8	9.1
N3	5200	5.3	6.0	7.1
N4	8700	4.0	4.6	5.2
EN	12170	3.6	4.0	4.3

Heights of Protection - The top elevations for the Floodgate structure and walls and dikes in Revere and along Lynn Harbor which are part of the Regional Plan are shown in Table 5. The three plans being considered vary the height of protection for the 100 year, 500 year and SPN storm levels of protection. The 500 year design storm will be used for comparing alignments 2 through 5 to Options 1 and 2. Then the 100 year and SPN design conditions will be used to optimize the option selected.

Type of Floodgates - The type of floodgates to be used to provide 8700 square feet (SF) of gated opening depends on their purpose, efficiency to pass flows, environmental concerns and size of the opening. Two general purpose for gates are needed, one for navigation and the other for flushing.

(1) Navigation Gate - model studies of the estuary tide levels showed the bottom sill of the Navigation gate would need to be at the bottom of the existing river navigation channel, about EL. - 18 ft. NGVD so as not to restrict low tide levels. The gate would be at least 100 feet wide. Thus provide a flow area at mid tide of 1800 SF. Several types of gates (Figure 8A & 8B) were considered but the Miter and Sector were evaluated in detail. The Miter gate, constructed using a braced ring cofferdam, was found to be most economical (see Table 14) with the low wave action at the mouth of the river compared to a Sector gate using a cellular cofferdam. A miter gate as shown in the Main Report is similar to two hinged doors which close on a bevel or miter. A hydraulic cylinder would open and close the gates in about 20 minutes. The gate would have unlimited clearance overhead. The width of the gate at Alignments 3 and 4 near the bridge would be the same as the bridge and, thus, held to 100 feet wide. At alignments 1, 2 and 5, a larger opening would be evaluated for technical and economic feasibility during final design. The drum gates concrete, excavation and cofferdam costs would have exceeded the Miter gate costs.

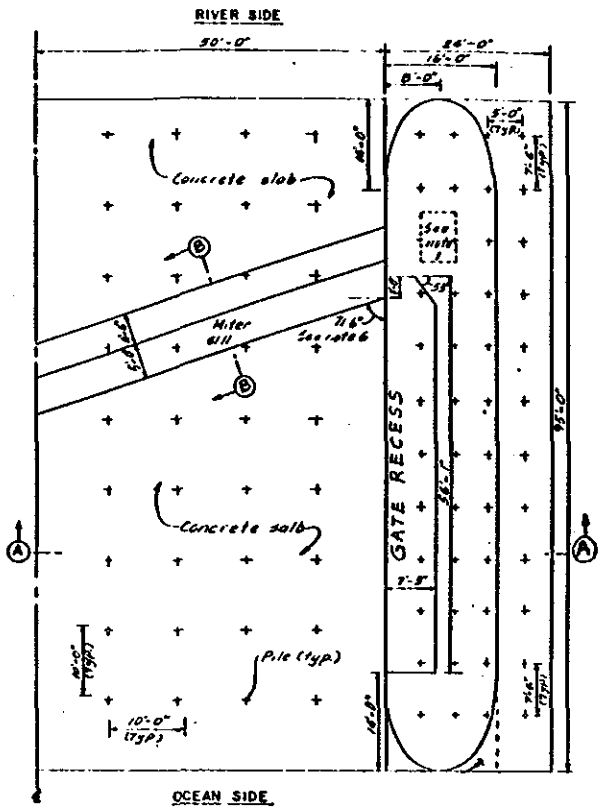
TABLE 14

COST COMPARISON - Miter vs. Sector Gate
($ Millions)

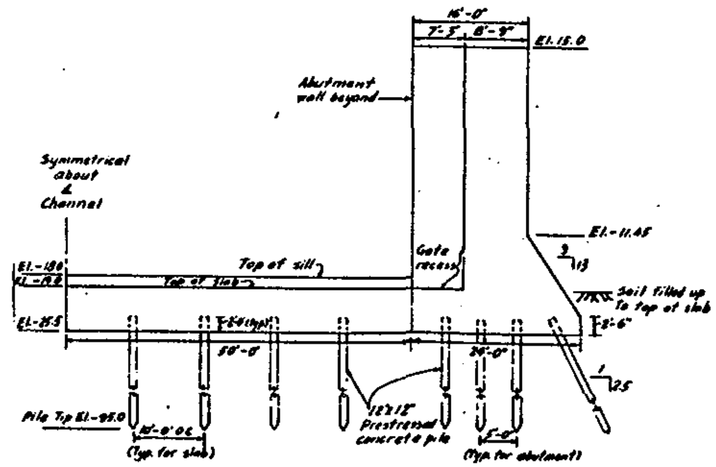
Navigation Gates		Miter Gate	Sector Gate
Gate (1 each)		$4.7	$ 7.5
Concrete		2.4	8.1
Bearing Piles		0.6	3.6
	TOTAL	$ 7.7	$ 19.2
Cofferdams Compared		$ 2.6 Ring	$ 13.1 Cellular

Navigation Gate Width Selection - Navigation criteria for design of the navigation opening considered the guidance in EM 1110-2-1611. The manual recommends various considerations for clearances between vessels and wind direction and navigating nearby bridges. Also, evaluation of currents, type and volume of traffic through the gates. In selecting the 100 foot width it was decided that for planning purposes and the various alignments being considered, the existing width of the navigation opening through the General Edwards Bridge should be used as a minimum, being 100 feet wide. Two alignments would connect directly with the 100 foot bridge openings. By keeping the 100 foot width for the other three alignments, the decision was made that it would not impose any new restrictions on navigation in the channel. With the exception of the (about) 40 foot wide Gen. Elec. fuel tankers, which enter once a month, all other vessels are less than half that wide. With the posted speed of 5 mph and two way traffic of two-twenty foot wide vessels, the 100 foot was considered reasonable. This is the existing restriction at the General Edwards Bridge. Further, there is a straight run between the Bridge and Floodgates without any bends in the channel. Recreation and fishing vessels currently wait until the fuel barge passes the bridge, once a month, before entering the opening.

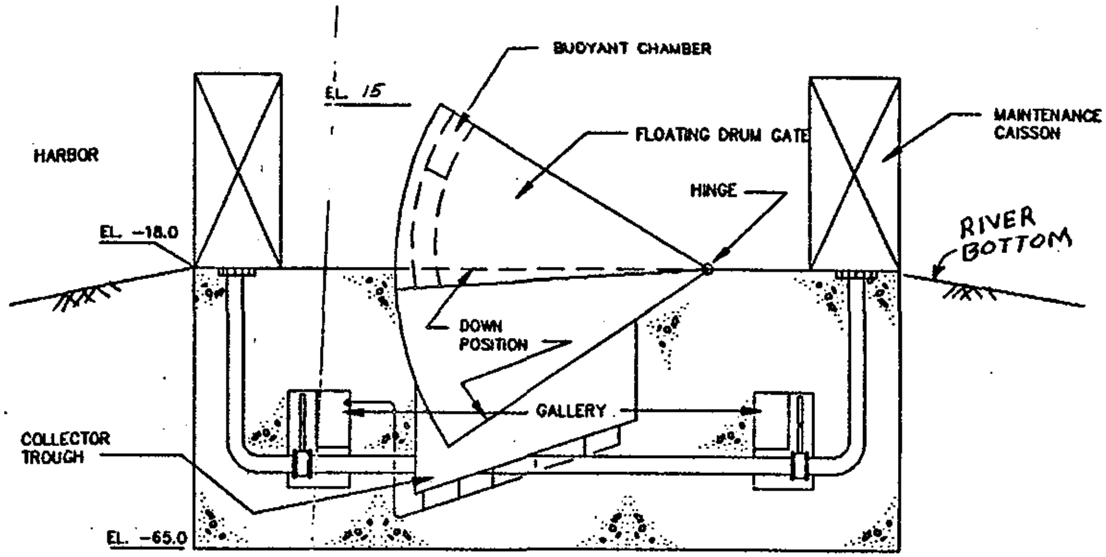
Therefore, the selection of a 100 foot width for the floodgates was based on a reasonable width so as not to create any more of a restriction than currently exists at the mouth of the Saugus River.



PLAN - MITER GATE STRUCTURE



SECTION A - A
MITER GATE



SECTION DRUM GATE

ALTERNATIVE NAVIGATION
MITER & DRUM GATES

FIGURE 8A

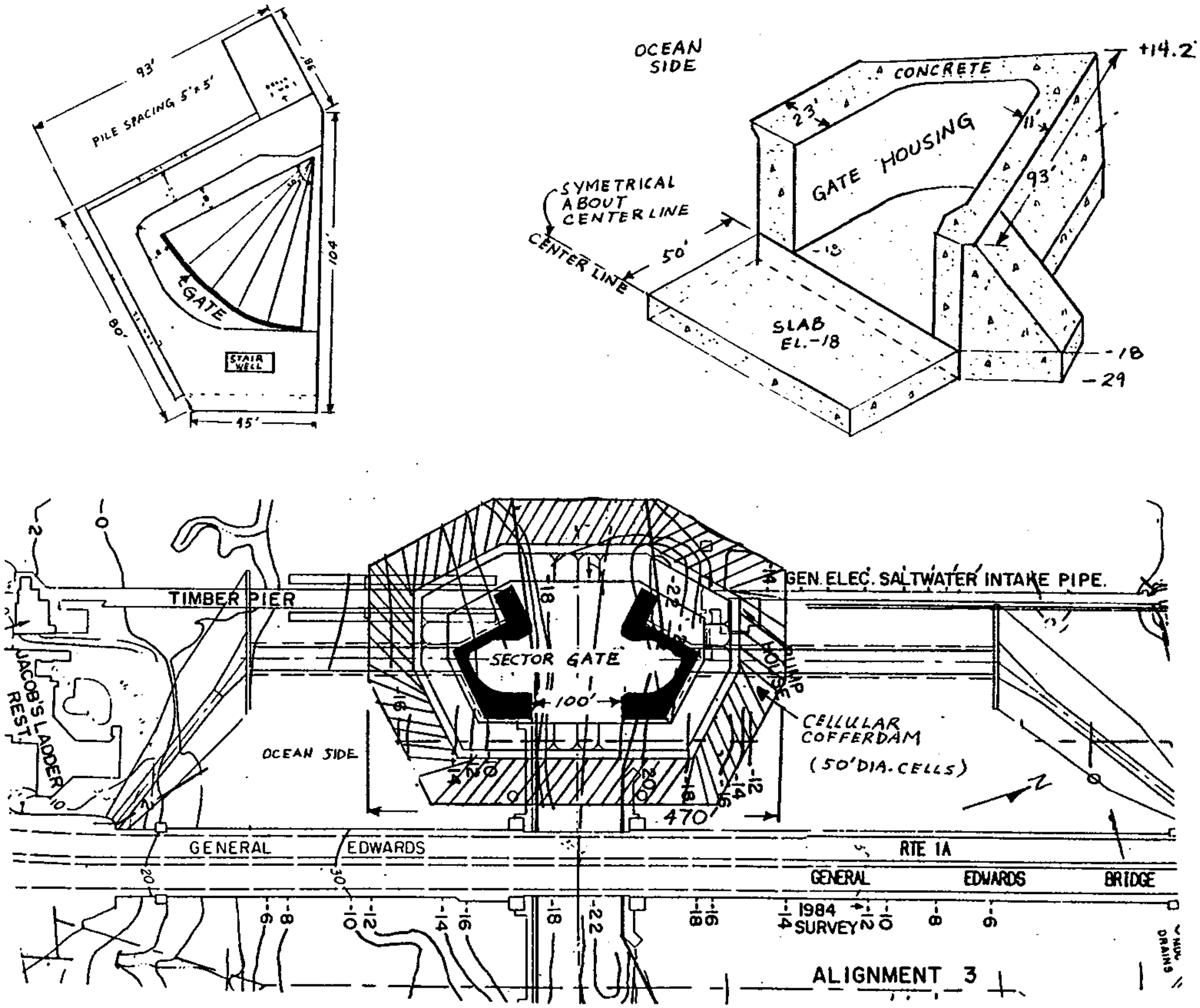


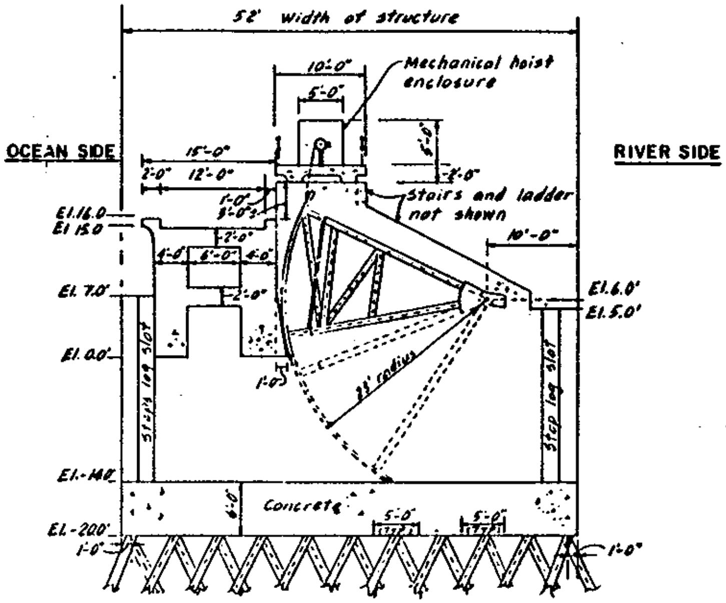
FIGURE 8B
ALTERNATIVE NAVIGATION
SECTOR GATE

If a wider navigation gate is needed several things would be considered. The cost per SF of flow area for the navigation gate is about $6100 per SF compared to about $3600 per SF for the flushing gates. The navigation gate sill could be raised from EL.-18 to EL.-13± (the Navigation Project recommended channel depth is EL.-12.6). This would help reduce the cost of a wider navigation gate. The flow area to EL.-18 could possibly be replaced by lowering at least two of the 50 foot wide flushing gates from EL.14 to -18. Detailed evaluation of the cost and dimension of openings would be accomplished in design. New marina's are also being proposed at the confluence of the Pines and Saugus River. The size of the vessels proposed for these marinas may also have a bearing on the width of the final navigation gate, as will other factors to be considered in final design.

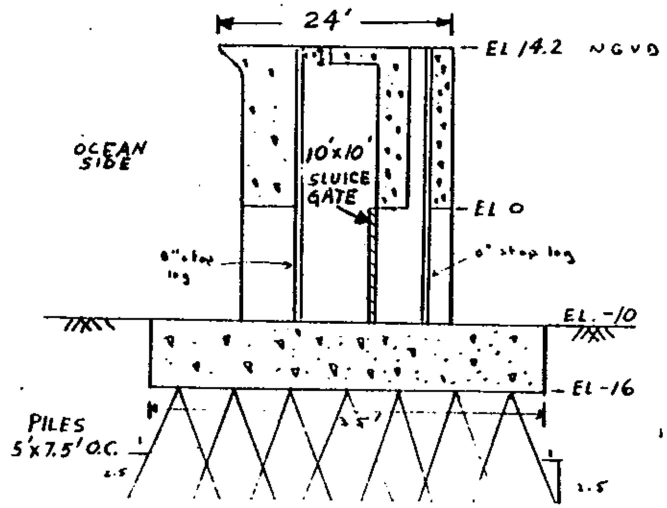
Flushing Gate Selection - Flushing gates would make up the rest of the 8700 SF, for a flow area or 6900 SF. Several types of gates were considered (Figure 8C). The Flap Gate was discarded since it did not have a positive closure. The Tainter and Sluice Gates were evaluated further. Fisheries biologist prefer the largest openings possible with gates near the bottom of the river, near the side of the channel and within 3 to 5 feet of the water surface. The top of the gates for maximum efficiency should be nearly totally submerged at mid tide, or with a top elevation at EL. 0.0 FT. NGVD. A variety (types and sizes) of gates were cost estimated. The gates were sized to all be the same size for ease of maintenance and construction. The bottom elevation was selected to reduce the amount of dredging, as much as possible, yet be spread out along the flow area of the river to facilitate fish passage and natural flow conditions. The type, number and size of gate found to be most economical and which also appeared to avoid significant impacts on biota in the area of the floodgate structure were:

Ten Tainter Gates for Alignments 1,2 and 5 which would provide 50 foot long (or eight 62.5 foot long for Alignment 3 and 4) and 14 foot high openings from EL. 0.0 ft. NGVD at the top and EL. 14.0 ft. NGVD at the bottom for a total flow area of 7000 SF. (with the navigation gate 8800 SF). The Tainter gate, is the type of gate which the Study Committee's visited at the Fox Point Project in Providence, Rhode Island, but not as high. Each of those gates were 40 feet by 40 feet and in the open position would allow boat traffic. The cost of 5 tainter gates constructed using a braced cofferdam is compared in Table 15 to 35 - (10'x 10') sluice gates using a cellular cofferdam which provide the same flow area.

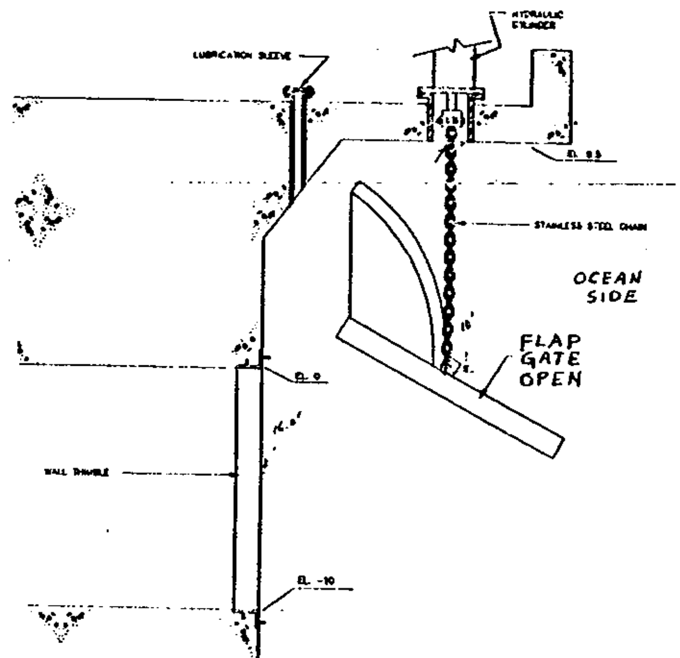
Top Elevation Floodgate Structure - The top of the floodgate structure at EL.13 to 15 ft. NGVD (100 yr. to SPN design) would be 3 feet above the Design Stillwater Tide Level (DSWL) based on the top of runup and about 8-10 feet above mean high tide, and 3-5 feet above the 1978 stillwater tide. The top elevations for structures in the Regional Plan are shown in Table 16. These gates would be held open in the up position and closed in about 15 to 20 minutes to close off a flood tide.



TAINTER GATE



SLUICE GATE



FLAP GATE

FIGURE 8C

ALTERNATIVE FLUSHING GATES

TABLE 15

COST COMPARISON - Tainter vs. Sluice Gate
($Millions)

Flushing Gate		Tainter Gates	Sluice Gates
Gates (3500 SF)		$ 3.9 (5 ea.)	$ 6.2 (35 ea.)
Concrete		3.2	5.2
Bearing Piles		2.8	2.6
	TOTAL	$ 9.9	$ 14.0
Cofferdams (Compared)		Braced $2.9	Cellular $8.0

Gated Size Sensitivity - The tainter gate was selected over the sluice gate after comparing the cost of similar gated area. The size or dimensions of the 14'x 50' tainter gates were established by: meeting the 6900 SF flow area, top elevations held at a minimum EL. 0 and then selecting a bottom of sill at or below the hydraulically required EL.-10 ft. NGVD. Based on the river profile to minimize dredging, a gate sill of EL.- 14 was selected. Other dimensions were considered, including a gate top elevation at mean high water (EL. 5), and also a gate top elevation to EL. 15, the design top elevation of the structure. All other dimensions would remain the same, with a width of 50 feet and sill at EL.- 14. The additional cost to raise the 10-tainter gates to a top of EL. 5 would be about $2 million less a savings in reinforced concrete of about $ 0.4 million. The net increased cost would be about $1.6 million. The additional cost for a top of gate at EL. 15 would be about $6 million less $1 million in concrete, or a net $5 million increase.

At the time of gate size selection, there was no overriding reason to select gates higher than EL. 0, and keeping the gates as low as possible for aesthetic reasons was important. Subsequent evaluation of the gates indicates, they may need to be raised a few feet to reduce flow construction at EL. 0. Also other concerns have included potential adverse affects on fish passage with water above EL. 0, the passage of ice through the openings at water levels near or above EL. 0 and sea level rise. During design these factors would be considered in developing final dimensions. The additional cost of raising the gates to mean high water, or about $1.6 million, is well within the total contingency for the flushing gates at $5.5 million. The sill elevation and width can also be varied during design to achieve the most efficient flow, cost and address the various concerns.

Floodgate Alignments - Five alternate floodgate alignments were considered, as shown on Plate 14.

(1) Alignment #1 - located about 500 feet east of the MDC Public fishing Pier. The structure would tie into the required Lynn Harbor dike to the north and into the Point of Pines wall to the south.

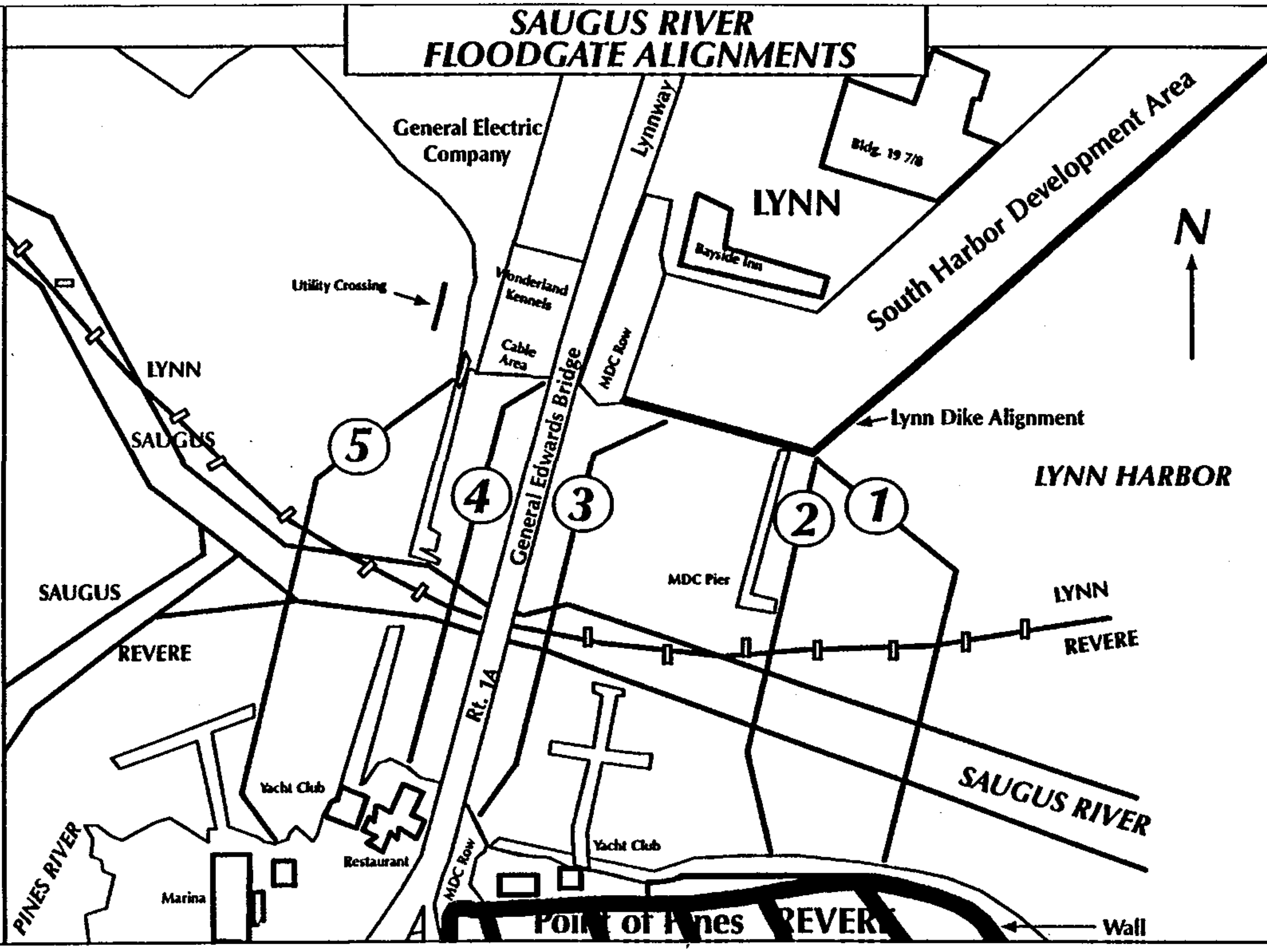

SAUGUS RIVER
FLOODGATE ALIGNMENTS
General Electric Company
Lynnway
Bldg. 19 7/8
LYNN
South Harbor Development Area
N
Bayside Inn
Utility Crossing
Wonderland Kennels
Cable Area
General Edwards Bridge
MDC Row
LYNN
SAUGUS
Lynn Dike Alignment
LYNN HARBOR
5
4
3
2
1
MDC Pier
SAUGUS
LYNN
REVERE
REVERE
Rt. 1A
SAUGUS RIVER
Yacht Club
Yacht Club
Restaurant
PINES RIVER
Marina
MDC Row
Wall

PLATE 14

(2) Alignment #2 - located about 700 feet east of the General Edwards Bridge, or 100 feet east of the MDC Pier. The floodgate structure would span the 1275 width of the Saugus River and tied into the Lynn Harbor dike to the North and Point of Pines' wall to the South.

(3) Alignment #3 - located about 100 to 150 feet east of the General Edwards Bridge. The floodgate structure would tie into the Lynn Harbor dike to the north. At the south end it would tie into the bridge embankment.

(4) Alignment #4 - located about 100 to 150 feet west of the bridge. The floodgates would tie into the bridge embankment at each end.

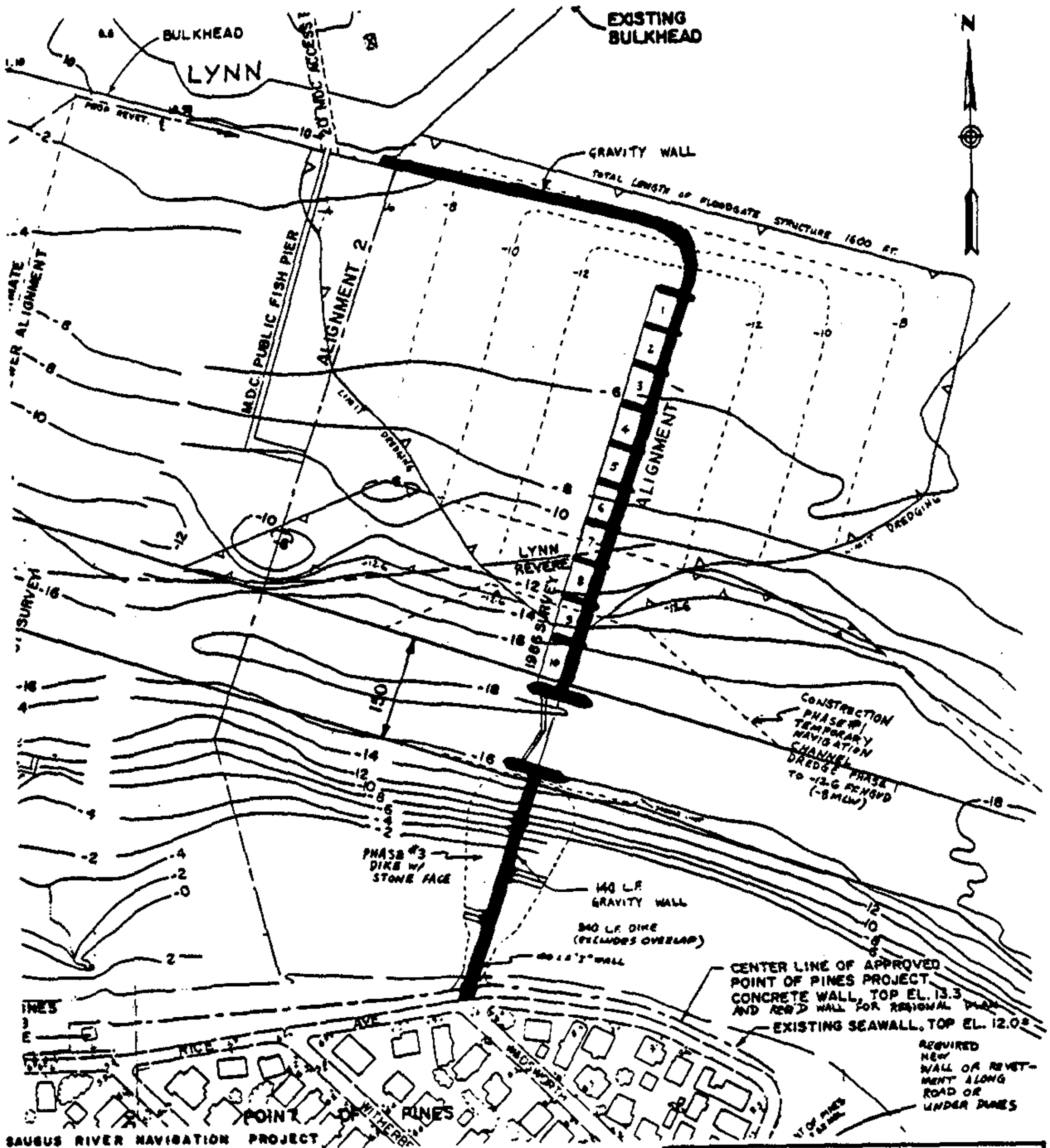
(5) Alignment #5 - located about 500 feet west of the bridge. The floodgates would tie into the shore which would require walls or dikes along the banks to the bridge embankment at each end.

The layout of the gates, that is, the number of gates north and south of the navigation gate depends on the Alignments 1 through 5 and the river bottom. For each alignment the gates are positioned along the river bottom for the least amount of dredging to reach EL. - 14 the bottom of the flushing gates. The navigation gate was centered on the proposed Federal Navigation Channel. For Alignments 3 and 4 on each side of the bridge, the gates are centered between the bridge piers to reduce flow impact on piers. The following describes each alignment.

. Alignment #1 (See Plate 15) - The total length of the floodgate structure is 1600 feet from the Lynn bulkhead to the Point of Pines (POP) seawall at Wadsworth Ave. No relocations would be required. There is concern whether the gates would cause erosion of the dunes at Point of Pines. The alignment reduces concerns for current impacts at the POP Yacht Club. Alignment 1 would have all 10-Flushing gates on the Lynn side of the navigation gate.

. Alignment #2 (See Plate 16 & 16A) - The total length of the floodgate structure is about 1300 feet from the Lynn bulkhead to POP's seawall at Witherbee Ave. The MDC fish pier may need to be removed if it is impacted by currents from the gates. If in design it would need to be removed, fishing activity is expected to be replaced by use of the floodgates structure. Alignment 2 would have one flushing or Tainter - 50 foot wide gate on the Revere side of the navigation gate and nine - Flushing (50 foot wide) gates on the Lynn side.

. Alignment #3 (See Plate 17) - The total length of the floodgate structure is 1400 feet from the Lynn bulkhead to the south bridge abutment. An additional 400 feet of dike is needed along the Lynn bulkhead. Relocation of part of the Point of Pines' Yacht Club moorings and the area's drainage system is required. A three foot layer of stone and gravel is needed for protection around and between the bridge piers, after possibly relocating the utility cables under the bridge. A temporary marina would be built for about 30 vessels which could not pass under adjacent spans (Clearance 20 feet at MHW) of the bridge when the



SAUGUS RIVER NAVIGATION PROJECT
RECOMMENDED
ENTRANCE CHANNEL

-8 FEET AT M.L.W. 150 FEET WIDE
(WIDENED AT BENDS)
(-8 FEET M.L.W. =-12.6 FEET N.G.V.D.)

HYDROGRAPHY CONTOURS FROM SURVEY OF 1986 ARE SHOWN AT N.G.V.D. DATUM FROM EL. -6 TO -22 FEET N.G.V.D.

CONTOURS FROM 2 TO -4 ARE FROM 1974 TOPOGRAPHY

CITY OF REVERE

SCALE 1" = 100'

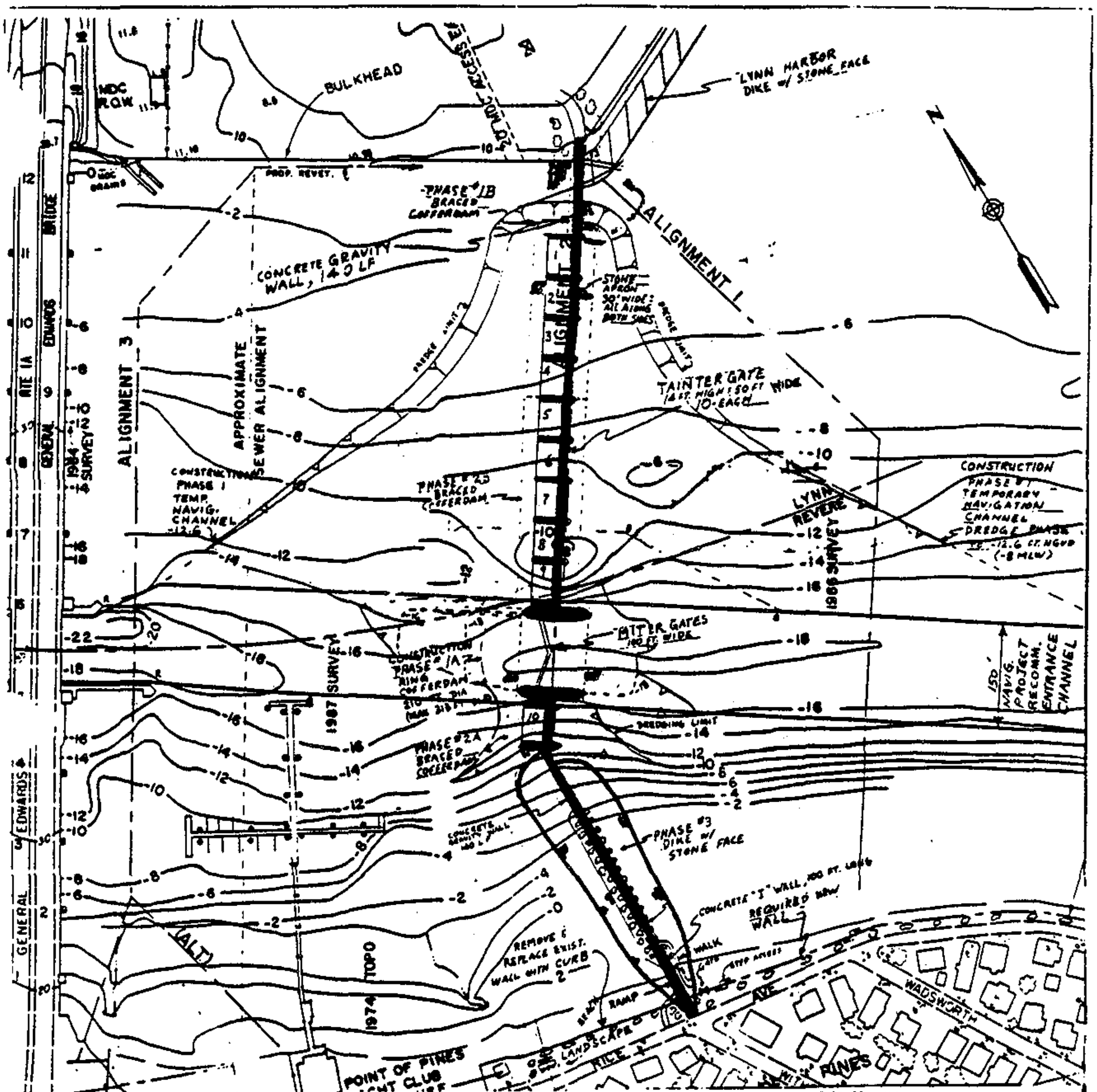
CITY OF LYNN

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

ALIGNMENT 1
SAUGUS RIVER
FLOODGATES "N4"

GENERAL PLAN
JUNE 1988

PLATE 15



CITY OF LYNN
DATE OF PHOTOGRAPHY 4-23-83
COMPILED AND CONTROLLED BY JAMES W SEWALL COMPANY, OLD TOWN, MAINE THROUGH PHOTOGRAMMETRIC METHODS

SAUGUS RIVER NAVIGATION PROJECT
RECOMMENDED
ENTRANCE CHANNEL

-8 FEET AT M.L.W. 150 FEET WIDE
(WIDENED AT BENDS)
(-8 FEET M.L.W. = -12.6 FEET N.G.V.D.)

HYDROGRAPHY CONTOURS FROM SURVEY OF 20 FEB 1986 ARE SHOWN AT N.G.V.D. DATUM FROM EL. -6 TO -22 FEET N.G.V.D.

CONTOURS FROM 2 TO -4 ARE FROM 1974 TOPOGRAPHY

500 FOOT GRID BASED ON MASSACHUSETTS RECTANGULAR GRID SYSTEM NATIONAL GEODETIC VERTICAL DATUM OF 1929

CONTOUR INTERVAL 2 FT.

CITY OF REVERE
DATE OF PHOTOGRAPHY 3-7-81
AERIAL DATA REPRODUCTION ASSOCIATES, INC PENNSAUKEN, N.J.
PEACE DALE, R.I.

100 0 100 200 300 FEET

SCALE 1" = 100'

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

ALIGNMENT 2
SAUGUS RIVER
FLOODGATES "N4"

GENERAL PLAN
SEP. 1988

Floodgate Structure

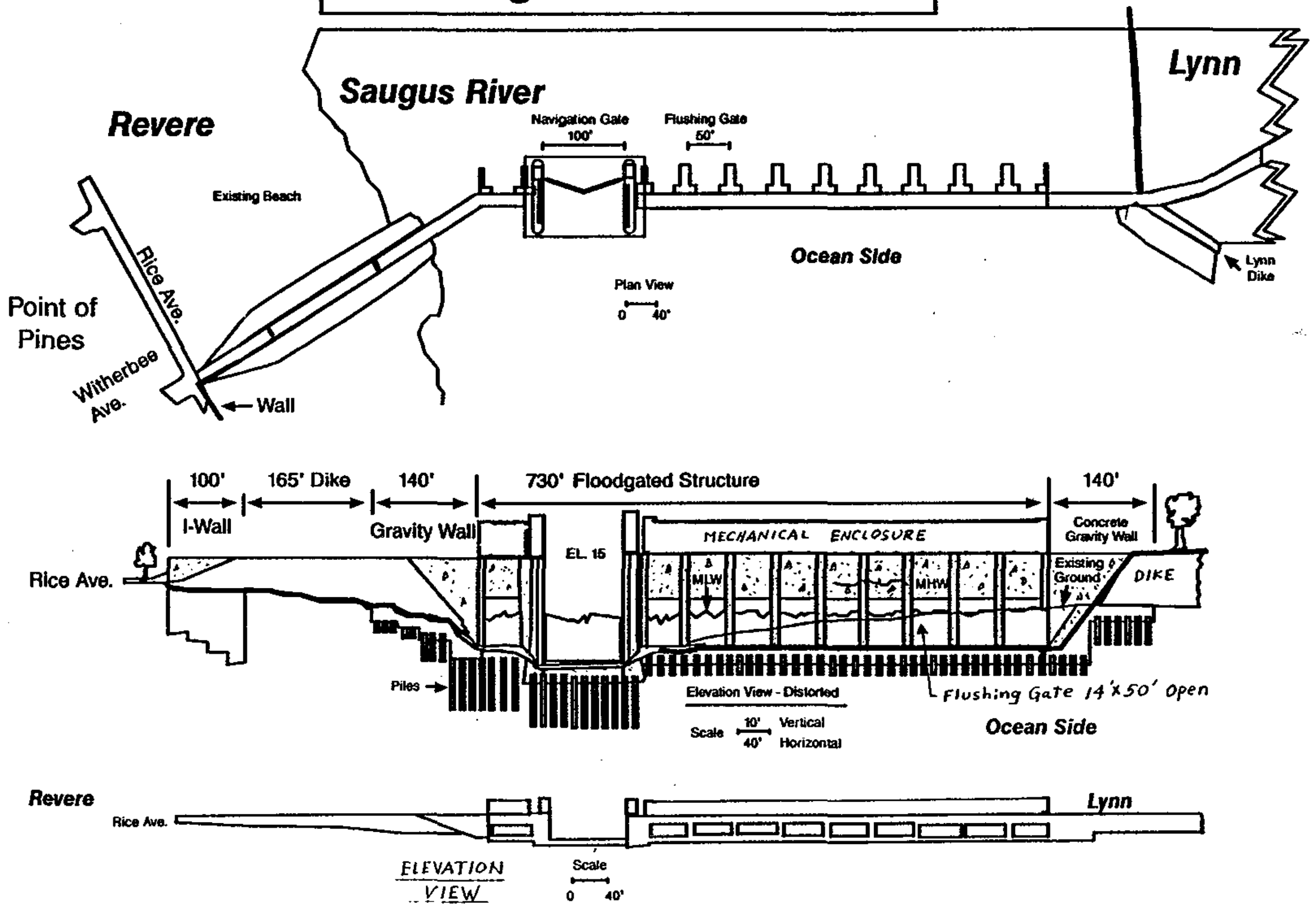
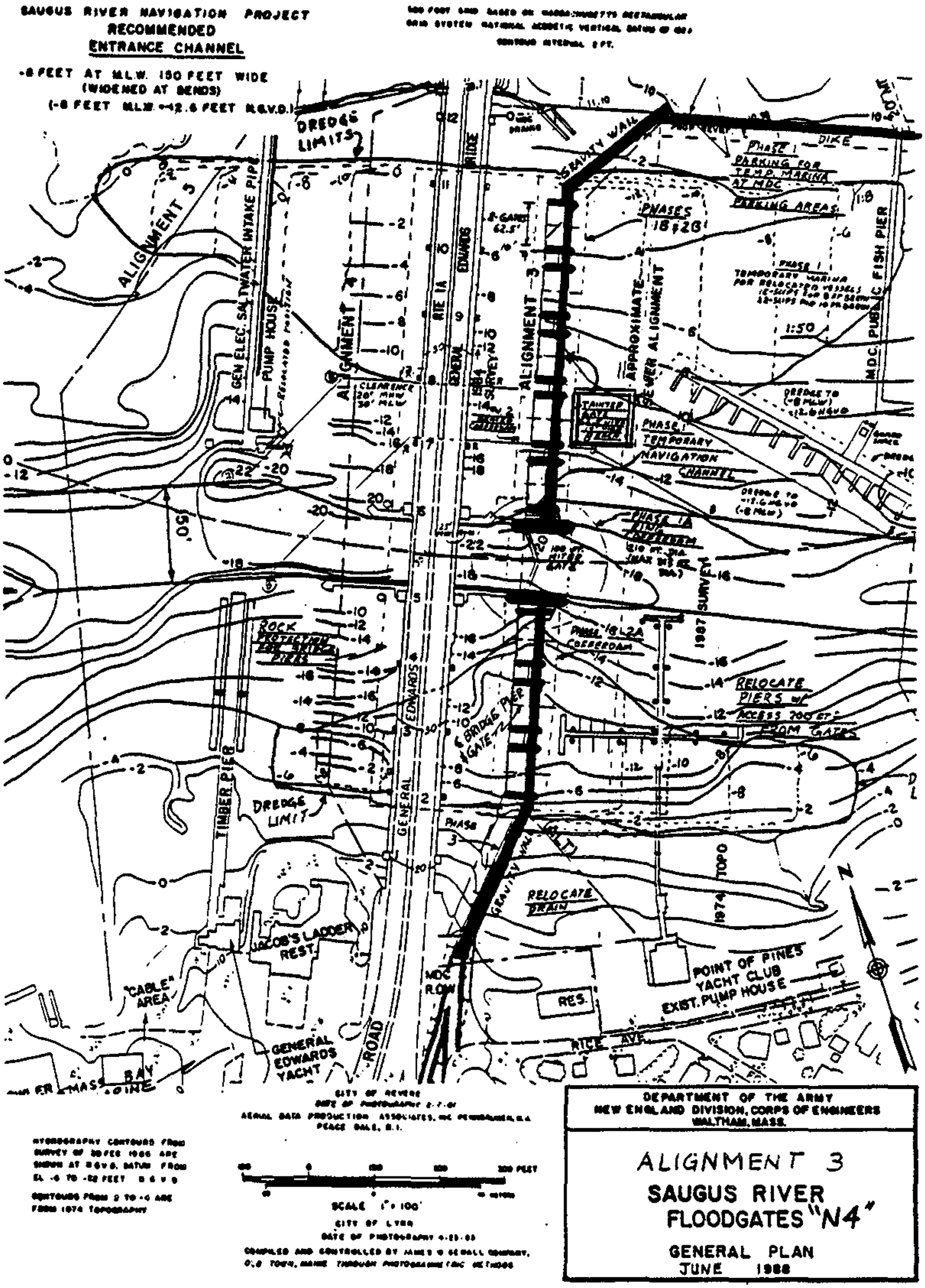


PLATE 16A



SAUGUS RIVER NAVIGATION PROJECT
RECOMMENDED
ENTRANCE CHANNEL
-8 FEET AT M.L.W. 150 FEET WIDE
(WIDENED AT BENDS)
DREDGE LIMITS
GRAVITY WALL
DIKE
PHASE I PARKING FOR TEMP. MARINA AT MDC PARKING AREAS
PHASES 1B & 2B
ALIGNMENT 5
GEN. ELEC. SALTWATER INTAKE PIPE
PUMP HOUSE
ALIGNMENT 4
RTE 1A
GENERAL EDWARDS BRIDGE
ALIGNMENT 3
APPROXIMATE SEWER ALIGNMENT
1:50
MDC PUBLIC FISH PIER
PHASE I TEMPORARY NAVIGATION CHANNEL
PHASE 1A
1987 SURVEY
ROCK PROTECTION FOR BRIDGE PIERS
RELOCATE PIERS w/ ACCESS 200 FT FROM GATES
DREDGE LIMIT
TIMBER PIER
GENERAL EDWARDS
GRAVITY WALL
RELOCATE DRAIN
1974 TOPO
JACOB'S LADDER REST.
"CABLE" AREA
GENERAL EDWARDS YACHT
ROAD
MDC R.O.W.
RES.
POINT OF PINES YACHT CLUB
EXIST. PUMP HOUSE
RICE AVE.
BAY
N
SCALE 1" = 100'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
ALIGNMENT 3
SAUGUS RIVER
FLOODGATES "N4"
GENERAL PLAN
JUNE 1988

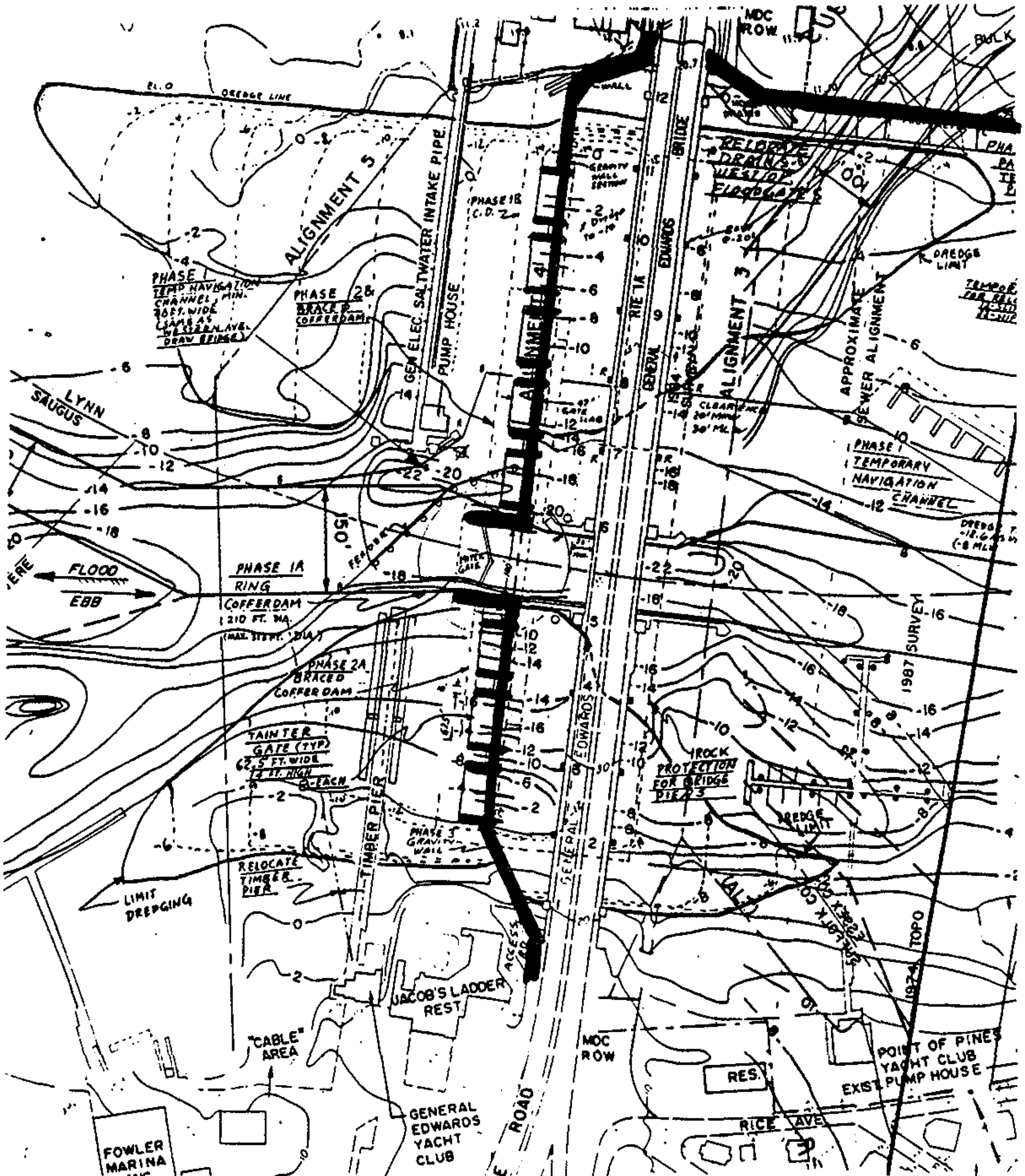
PLATE 17

lift span section of the bridge and navigation channel is closed for one and a half years during construction. General Electric would spend additional funds to transport their fuel by truck since their tankers could not use the channel during this period. A temporary channel would need to be provided between adjacent spans of the bridge during the construction of the navigation gate. Some modification to the General Electric salt water intake pier may be required to facilitate temporary navigation passage. Working this close to the bridge is bound to cause delays in construction activities. Alignments 3 and 4 would have eight 62.5 foot wide gates, three on its Revere side and five on the Lynn side.

. Alignment #4 (See Plate 18) - The total length of the structure is 1350 feet. An additional 700 feet of dike is needed along the Lynn bulkhead on the east side of the bridge. Stone protection and cable relocation is required under the bridge. It is expected that all or part of both the General Electric pipeline pier would need to be relocated during construction A temporary marina is required and trucking of General Electric's fuel. Additional sub-surface utility cables at the alignment may also need to be relocated. Higher real estate impacts would result at each abutment due to existing or potential commercial developments, and the limited access at one or both abutments. There would be delays in navigation passage during the one year construction due to restricted passage and sharp turns in a temporary channel through the bridge. The Lynnway drainage system would be relocated to outlet behind the gates to provide the city drainage during storm conditions. Alignments No. 4 and No.5 would not protect the General Edwards Bridge piers, girders or abutments during storm conditions. The north and south road girders hang low at EL.11 ft. NGVD - well within the wave limits of a 10 year tidal storm.

. Alignment #5 (See Plate 19) This floodgate structure is 1620 feet long from the south riverbank to the Gen. Electric pipeline pier. In addition about 1600 feet of additional shoreline protection is needed along the south abutment to the bridge and from the north abutment past the bridge to Lynn Harbor. Relocation of the Lynnway drainage system would be included as well as the Gen. Edwards pier which is too close to the gates due to impacts from currents. The alignment would also interfere with a proposed expanded marina in this area.

The General Electric would need to truck their fuel due to a restricted channel during construction. The General Electric pipeline would require some modification since it is along the dike alignment. Impacts along both riverbanks to commercial real estate would be significant due to limited access and especially through new development planned on the south abutment. Delays in the passage of 400 vessels through the initial one year construction site can be anticipated as with Alignments 3 and 4. Alignment 5 would above ten-50 foot wide gates with five on each side. The concrete structure housing the gates would be connected to the shore with either a concrete wall or stone faced dike.



SCALE 1" = 100'

SAUGUS RIVER NAVIGATION PROJECT
RECOMMENDED
ENTRANCE CHANNEL

-8 FEET AT MLW 150 FEET WIDE
(WIDENED AT BENDS)
(-8 FEET MLW = -12.6 FEET N.G.V.D.)

CONTOUR INTERVAL 2 FT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

ALIGNMENT 4
SAUGUS RIVER
FLOODGATES "N4"
GENERAL PLAN
JUNE 1988

PLATE 18

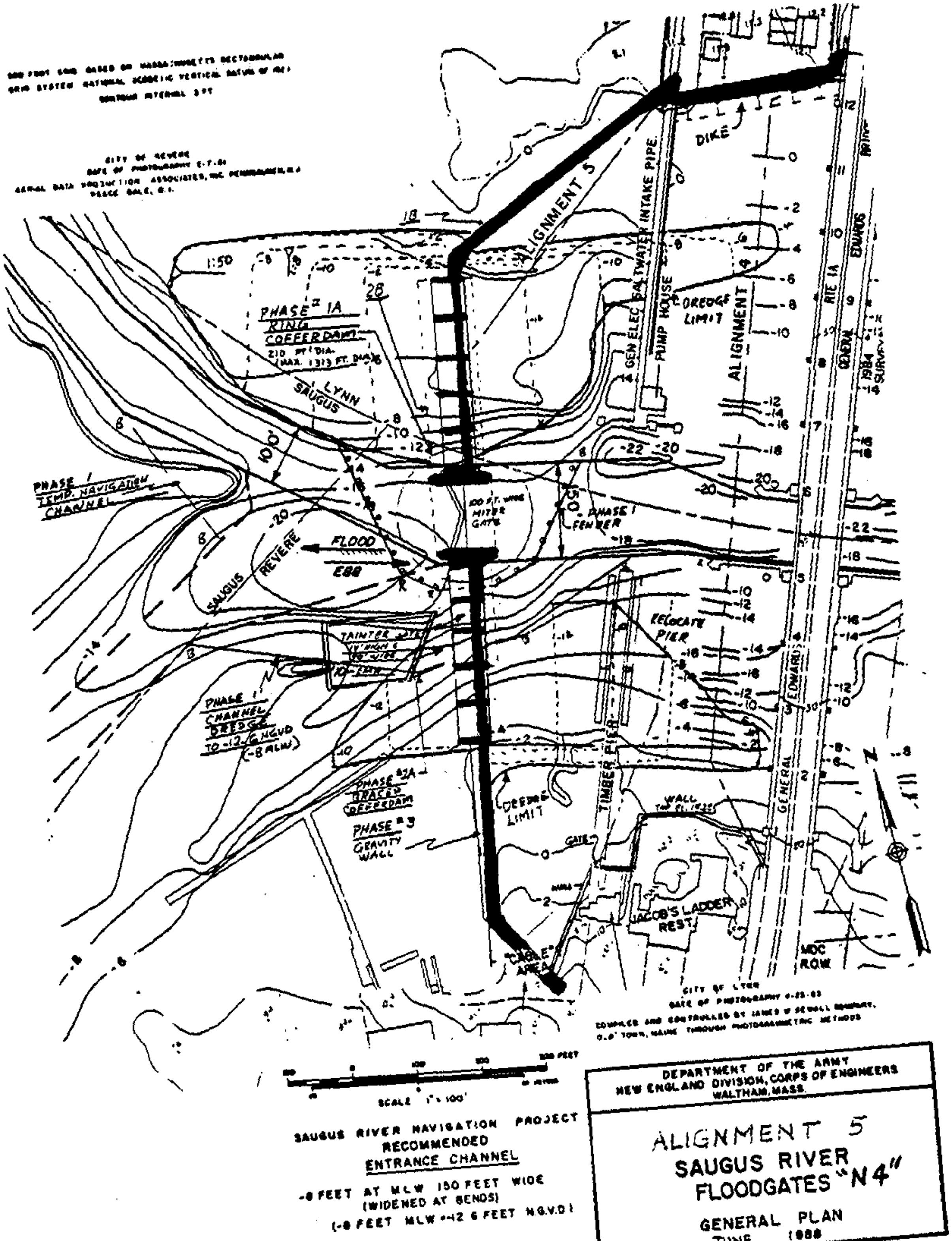

ALIGNMENT 5
DIKE
GEN ELEC SALTWATER INTAKE PIPE
PUMP HOUSE
DREDGE LIMIT
ALIGNMENT 4
RTE 1A
GENERAL EDWARDS
1984 SURVEY
PHASE II 1A RING COFFERDAM
210 FT DIA.
LYNN
SAUGUS
PHASE I TEMP. NAVIGATION CHANNEL
100 FT. WIDE MITER GATE
PHASE I FENDER
FLOOD
EBB
SAUGUS REVERE
TAINTER GATE
RELOCATE PIER
PHASE CHANNEL DREDGE TO -12.6 NGVD (-8 MLW)
PHASE #2A BRACED COFFERDAM
PHASE #3 GRAVITY WALL
DREDGE LIMIT
TIMBER PIER
GENERAL EDWARDS
WALL
GATE
JACOB'S LADDER REST.
MDC ROW
"CABLE" AREA
SCALE 1" = 100'
SAUGUS RIVER NAVIGATION PROJECT
RECOMMENDED
ENTRANCE CHANNEL
-8 FEET AT MLW 150 FEET WIDE
(WIDENED AT BENDS)
(-8 FEET MLW = -12.6 FEET N.G.V.D.)
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
ALIGNMENT 5
SAUGUS RIVER
FLOODGATES "N4"
GENERAL PLAN
JUNE 1988

PLATE 19

Floodgate Dike vs. Gravity Wall Cost Comparison - The floodgate structure for Alignments 1 and 2 ties into the Point of Pines wall along Rice Ave. A steel sheet pile I-wall with a concrete cap is used for the 100 foot length of structure connecting to the Rice Ave. wall. The 100 foot length is needed to run along side an earthen ramp access from Rice Ave. to the top of the floodgate structure. Between the I-Wall and Revere Flushing Gate, a distance of about 305 feet, three alternatives were evaluated:

a) a 140 foot gravity wall and 165 foot dike.
b) a 305 foot gravity wall.
c) a 305 foot dike and retaining wall at the flushing gate.

Alternative (a) had the lowest cost with a dike cost of $737,000 plus the gravity wall at a cost of $1,968,000. The wall cost was estimated from a wall section 29 feet above the river bottom.

If foundation conditions during design should determine the dike section is not technically feasible, it could be replaced by a gravity wall averaging 15 feet high above the river bed. The additional 165 foot length of wall would cost about $1.2 million, or increase the project cost about $460,000 - about a 0.7% increase in project cost.

Floodgate Operation - The openings and operation of the floodgates are being designed so that there would be no significant impact on the ecology of the estuary or navigation with gates in the open or closed condition.

Gates Open Condition - The 8800 square feet of gated openings meet the navigation and estuary criteria. All gates would remain open about 99.9 percent of the time - except for 6 to 10 hours per year. With the gates open during the year, non-storm high tides normally rise to about EL.7.5 Ft. NGVD with no significant change to the estuary. From topographic mapping and marsh profiles the vegetated marsh surface ranges between about EL.4 to 6. The tidal wetlands would be covered during typical closures at elevation 7.0 feet NGVD, as field investigations determined all of the tidal wetland is contained below this level.

(a) With gates open there would be no significant change in tide levels (0.05 ft. or less drop), or volume of salt water flushing (average 0 to max. 1% less volume). (If I-95 embankment is totally breached by others, normal tides could rise about one half foot in Revere to one foot in Saugus upstream of I-95, and estuary volume increase about 10%) however this is not expected to occur. Another 10% increase would result from a one foot sea level rise.

TABLE 16

REGIONAL PLAN FEATURES
DESIGN TOP ELEVATIONS IN FT.NGVD

			CHANCE OF OCCURRENCE EACH YEAR		
Storm event:		Storm event:	1% 100 YR. (1978)	0.2% 500 YR.	NONE ASSIGNED SPN
Broad Sound Design Stillwater Tide Level (DSWL):			EL.10.3	EL.11.2	EL.12.0
			Top of Structures		
Saugus R. Floodgate Structure					
Alignments 1, 2, 3, 4, & 5			13.3	14.2	15.0
Lynn Harbor and Structures					
Reach	Length	Type			
A	0 to 700'*	Dike	13.0	14.0	15.0
B	1800'	"	15.0	16.0	17.0
C	1500'	"	13.3	14.0	15.0
D	3100'	Wall	13.3	14.0	15.0
E	1100'	Dike	12.3	14.0	15.0
F1	1120'	Ground Surface (EL. 13 Ground by others)			
		Wall	N/A	N/A	14.0
F2	280'	Wall	12.3	13.2	14.0

* Floodgates Aligns # 1 + 2 - Reach A is not required; Align #3 needs 400'; 4 + 5 need 700.

Revere Beach Boulevard:					
B1	1300'	Park Dike	21.0	22.0	23.0
B2	1450'	Park Dike	21.0	22.0	23.0
	420'	Wall	21.0	22.0	23.0
M Ponding Area Wall (500')			10.0	11.0	12.0
Point of Pines for floodgate Alignment, 1 and 2					
A	230'	Revetment (Wall @ 16.5)	13.2,1:3	13.2,1:3	13.2,1:3
B	440'	Revetment	16,1:3	18.0,1:3	18.5,1:3
C	460'	Revet. (Wall @ 16.4)	16,1:3	16.5,1:3	17,1:3
D	420'	Revet. (Wall @ 15.4)	14.5,1:3	16.5,1:3	17,1:3
E	1600'	Revet.*	13.0,1:3	15,1	16,1:3
F	700'	Wall*	13.3	14.2	15.0
F	200'	Cap,Wall*	12.3	13.2	14.0

* Minimum, wall and revetment top at 2 feet above the floodgate's DSWL.

(b) In the estuary, upstream of the gates, no significant change in currents, salinity or water quality is expected due to negligible changes in tides and flushing.

(c) Maximum average currents during a Mean Tidal Range would range from about 1.3 feet per second (0.8 knots) today at the bridge to about 1.7 fps (1K) at the N4 tide gates. Changes in river currents would be analyzed during design. (The Pines River at Rt. 107, maximum currents today, are about (1.7K) during a Mean Tidal Range.)

(d) At the tide gates, maximum average currents during a Mean Spring Tidal range would be about 2.1 fps and at the bridge 1.7 fps. (The Blynman Canal entrance to Gloucester Harbor for this range is 3.3 K or about 5.6 fps for comparison by those who navigate this harbor.)

(e) The original navigation current criteria of <u>Not to Exceed About 3 Knots</u> for this project would be met for the Predicted High Astronomic Tide Range. In order for vessels to navigate with or against a 3K current, they would need to increase their speed about 40% or 4.2 K for adequate control. Navigation is posted at 5 miles per hour (or 4.3 K) near the General Edwards Bridge. Slightly higher currents at the gates should not pose a significant problem to navigation since the reported capability of lobster boats is 8 to 10 K and sail boats is 5 to 6 K. The fuel barge and tanker which service General Electric have a capability of 9K. The fuel dispatcher reported that a 3K current during mid-tide would not be a problem through the 100 foot navigation gate. Currently, the barge and tanker enter the river at high tide and depart a half hour before the following high tide due to river depth restrictions. (Currents approach "0"K at high tide). If the gates are far enough away from a yacht club, the currents should not pose a problem to cutting across currents. In the navigation opening, model studies will determine if any vessel would have a problem.

. <u>Gates Closed Condition</u> - Gates would be closed if the ocean tide was expected to rise to or above 8 feet NGVD (est. start of damages) or above, and generally speaking the gates would probably close at about 7 feet NGVD for storage of interior runoff. However, consideration will be given to occurrence of: light, moderate, or heavy rainfall, wind direction and velocity (because of estuary wave action and wind tide), below freezing temperatures (icy streets), snowbanks (street drainage). Additionally, if an unusually severe storm event was expected with hurricane or near hurricane force winds, the floodgates would probably be closed at somewhat lower elevations. Closure would be estimated to occur, based on a review of observed storm tides, between 2 and 3 times per year. Table 17A shows the 56 times from 1976 to 1986 when tides reached or exceeded EL.7.5 in Boston. The gates would have been closed about half the times, e.g. 28 times in eleven years or an average about 2 to 3 times per year as shown. The gates would generally be closed from mid-October to mid-February.

TABLE 17A
OBSERVED TIDES ABOVE 7.5 Ft. NGVD BOSTON HARBOR

MONTH	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
						YEAR					
JAN.		10- 7.68	9- 8.62	25- 9.26 26- 7.78 27- 8.00 28- 8.49 29- 8.32 30- 7.96 31- 7.55			10- 7.81	29- 7.63 30- 7.52			
FEB.	17- 7.56		6- 7.55 6-10.04 7-10.32 7- 7.66 8- 7.90	26- 8.42		7- 8.69		26- 7.50	17- 7.61 18- 7.48	6- 7.50	
MAR.	16- 8.65	23- 7.72							20- 7.50		
APR.		6- 7.92							15- 7.63 16- 7.78		24- 7.77
MAY										7- 7.62	24- 7.52 26- 7.55
JUNE		2- 7.51					22- 7.63				22- 7.55
JULY		1- 7.50									
AUG.											
SEPT.											
OCT.		14- 7.70		7- 7.53	25- 7.66					15- 7.45 27- 5.90	
NOV.		12- 7.54 13- 7.61			23- 7.64	15- 7.81 16- 7.58		5- 7.93			
DEC.	20- 7.56 21- 7.67					10- 7.88 11- 7.99 12- 7.93				12- 7.96 13- 7.55	30 - 7.75

Note: Preliminary estimates indicate that the floodgates would be closed for about half of these events, generally from mid-October to mid-February.

(a) FREQUENT STORMS: 90% of all storm tides: reaching EL. 8 to EL. 9 ft. NGVD. Each closure would occur when the ocean reached about EL. 7 ft. NGVD and remain closed for 1 to 2 hours until the tide drops to about EL. 7. With 2 to 3 closures per year, gates would be closed a total of about 6 to 10 hours per year, or 0.1 percent of the time.

1) Tides remain in the estuary and wetlands are submerged about the same length of time as natural conditions.

2) No significant changes in water quality, salinity or currents would be anticipated to occur with frequent storms. With these more frequent operations little storage of interior runoff would occur during closure. Generally, one foot of storage would be made available (between Elev. 7.0 and 8.0 ft. NGVD).

(b) RARE STORMS: Rare storms, those exceeding a stillwater tide elevation of 9 feet NGVD, include 10 percent of all storm tides. A rare storm event such as the 100 year-1978 storm with a stillwater tide elevation of 10.3 ft. NGVD, would likely occur once in 100 years. The gates would have been closed during the peak of the latter four consecutive high tides during the storm. Maximum closure would have lasted about six hours during each of the two peak tides. The total time gates would have been closed during the four high tides would be about 20 hours. This total closure time occurring about once in 100 years represents a very small percent of the time, about 0.01 percent.

During the rarer severe coastal storms and hurricanes, more interior storage, ranging from EL.7 to a maximum of EL.+2 could be made available for the storage depending on the volume of interior runoff and tidal overtopping expected, by closing the gates at lower than 7.0 ft. NGVD.

Water Quality and Estuary Dynamics - With the selection of the 8700 SF gated area (N4) below EL.0.0 ft. NGVD, there would be no significant changes in flushing or tide levels up to about a two foot sea level rise (Tables 18 & 19). The gates would initially remain open 99.9 percent of the time, although close more frequently with sea level rise (Table 17B).

Table 17B
Gate Closure with
Sea Level Rise

	Today	Over 100 years with SEA LEVEL RISE OF 1 ft.	2 ft.
Average Yearly Closures:	2-3	35-45	175-225
Typical Period of gate Closure: (Hrs)	1-2	2-3	3-4
Percent of Time Open: (Approx.)	99.9%	99%	92%

TABLE 18
Existing Condition
Change in Estuary with Gates

	GATE SCHEME N3	GATE SCHEME N4
Gated Flow Area (SF)	5200	8700
Change in Estuary High Tide Levels	-0.05	Nil
Change in Estuary Low Tide Levels (Ft.)	Nil	Nil
Change in estuary Flushing Volume (%)	-0.5 to -3.0	Less than 0.1%

TABLE 19

Estuary Flushing With/Without
Gates and Sea Level Rise

Scenario	2087 Sea Level Rise (feet)	Percent Change in Estuary Flushing Volume: Without Project Mean Range (50%)	Without Project Max. Astron. (.01%)	Closure @ EL.7.5± With Gate Scheme N4 Mean Range (50%)	With Gate Scheme N4 Max. Astron. (0.01%)
Project Historic Rise	0.8	+ 9%	+15%	+ 9%	- 2%
NRC Case I	1.6	+ 22	+34	+22	- 4
NRC Case II	2.9	+ 56	+60	+42	- 8
NRC Case III	4.2	+100	+80	+29	-14

If indications are in a few decades that a two foot rise or more will occur over the project life, the project would need to be investigated to determine those changes in the project needed to maintain a high level of protection. Decisions would need to be made whether to raise structures along the Lynn and Revere shore; whether to continue frequent closures, or to construct one to two foot high earth berms or walls around developed areas. This would raise the start of damages and reduce the number of closures. The one foot rise can be expected over the next 100 years, however a two foot or higher level of rise are speculative, and considerable information is needed to predict accelerated rise with any degree of accuracy.

Thus in the open condition there should be no significant impact on water quality for a reasonable rate of rise. In the closed condition, the gates would be closed for such a a short period of time, that any concentration of pollutants should be dispelled when gates are opened and the estuary flushes.

Normally very little runoff or precipitation accompanies a coastal storm, if it does, normally snow or light precipitation would accompany a Northeaster. There is a very rare chance a 10% runoff would accompany a 100 year tidal storm. The Blizzard of '78 had only snow.

Due to the low amount of freshwater normally to be stored in the estuary and infrequency of any significant amount of runoff, and short closure duration even with sea level rise, no significant impact should occur with gate closure which is normally accompanied by wind and waves which would continue to mix minimal pollutants in the estuary.

Flood Storage in the Estuary - In order to effectively operate the floodgate plan without causing damages, it is necessary to assure the preservation of the needed storage area around the estuary during storm conditions of high tides which may be accompanied by significant runoff from the watershed and wave overtopping. Although a significant amount of runoff rarely accompanies a coastal storm, the project is nevertheless designed to accommodate various "design conditions" of "Interior Storage Capacity Requirements" from extreme high tides accompanied by high runoff events. Table 20 shows the hydrologic design criteria adopted for the 100 year, 500 year and SPN design tides and the estimated time of maximum gate closure for one tide. The "wave overtopping" includes the shorefront at the North end of Revere Beach and at Point of Pines. The volume of interior runoff from the Saugus River measured just below the Saugus Iron Works and from local drainage areas is shown by either the frequency of runoff (10% or 10 year run off, 2% or 50 year, and to 1% or 100 year) or by inches of runoff. For the SPN Design Storm an estimated 5800 acre - feet (Ac-Ft.) of storage would be needed and a closure at El. +2 would likely result. Total available storage to EL. 8 is currently about 6000 Ac - Ft. With protection of the estuary to the EL. 7 contour line would assure at least 5400 AF of storage.

The EL.7 contour line was selected since it generally falls along the banks bordering the estuary. The EL.8 contour reaches developed properties, and regulatory control to that limit would likely cause problems to property owners. The EL.7 contour includes about 1500 acres around the open estuary. The 1500 was determined from aerial photo interpretation of the water surface. There may be another 50 Acres within the EL.7 contour of the estuary where the water surface was not discernible on aerial photos. (Note: There is about another 100 acres of estuary (for a total of about 1650 acres) which is partially land locked and not included in the 1550 acres). The methods of protecting the storage area are explained in the main report.

TABLE 20

INTERIOR STORAGE CAPACITY REQUIREMENTS

	1% (100 yr) Design Tide	0.2% (500 yr) Design Tide	SPN Design Tide
Gate Closure:	4.5 hours	5.5 hours	6 hours
Saugus River Inflow (26 sq mi)	340 Ac-Ft (10%Q=900cfs)	600 Ac-Ft (2%Q=1300)	750 Ac-Ft (1%Q=1500)
Local Runoff (21 sq mi)	1650 Ac-Ft (2.2" R.O.)	3100 Ac-Ft (3.1" R.O.)	3500 Ac-Ft (3.5" R.O.)
Wave Overtopping	325 Ac-Ft	690 Ac-Ft	1560 Ac-Ft
TOTAL	2300 Ac-Ft	4400 Ac-Ft	5800 Ac-Ft

The protection of the Saugus River tidal estuary storage is important for hydrologic and hydraulic reasons. The existing storage in the estuary is sufficient to store the freshwater runoff from the interior drainage area of 47 square miles when the tidal floodgates would be closed during coastal storms to protect against ocean flooding. The large storage capacity of the estuary precludes the need for an extremely expensive pumping station.

Recent field observations taken around portions of the estuary, namely Oak Island, Revere Beach Backshore and the Ballard Street area of East Saugus, during this ongoing feasibility study indicate that the start of significant damage is about elevation 8 feet NGVD. As a result of these observations, the Saugus River tidal floodgates would be closed if the ocean tide level is expected to rise to, or exceed elevation 8 feet; and the gates would be closed when the incoming tide is at or below 7 feet NGVD. However, the actual initiation of closure would be dependent on the severity of the storm, the length of time the gates would expect to be closed, the anticipated rainfall, interior runoff, wind and wave action within the estuary, and the other meteorologic conditions. During the construction phase of the project when the specific regulation procedures will be prepared, additional detailed field investigators would be undertaken to refine the start of damage elevation.

In addition, it is anticipated that this proposed method of operation will not have adverse impact on navigation, the existing marsh vegetation or wildlife, and very little or no impact on water quality. The proposed navigation gate width of 100 feet plus the ten 50 feet wide tainter gate openings will be model-tested by the Waterways Experiment Station during the design phase to insure there will be no significant impacts on navigation, the existing tidal flushing and/or water levels within the estuary.

There are several items which the project needs included in the local assurances. The first is to insure that an adequate amount of existing interior storage capacity is protected for future operational purposes. This does not state that filling of the floodplain cannot occur; however, compensating storage has to be provided. It is also noted that storage in the estuary is based on area-capacity curves developed during the study, and that refinements to area-capacity curves would be made during the design phase when more detailed mapping is available.

It's recognized that once the floodgate structure is built and is being operated to prevent flooding at or above 8 feet +NGVD - that FEMA and/or the local communities will be striving to lower the existing base flood level within the estuary, for flood insurance purposes. This attempt to lower the base flood level is appropriate and the Corps fully understands the reason for FEMA establishing 100 year levels for flood insurance purposes. Most flood levels are based on a statistical array of natural occurring events; however, the area behind the floodgates is a special situation.

Not withstanding the conservative design for the project, it is prudent to limit future potential flood prone development around the estuary as well as minimize future adverse impacts on project operations from these new developments, by assuming a "safety freeboard" zone that is a little higher than the project's operating criteria. Several reasons for this approach will include:

a. Storm rainfall significantly exceeding the forecast rainfall when the gate is closed. In July 1987, the nearby Quincy/Milton area experienced torrential rainfall of about 6 inches in 2 hours. This intense rainfall, which was not forecast, caused serious flood conditions.

b. Accident, delay or health problems of personal traveling to staff the floodgates during off-duty hours which may delay closure until backup personnel reach the floodgates.

c. Storm surge significantly greater than forecast because of unexpected localized storm conditions.

d. Low street levels with inadequately designed storm drainage.

With all of the above as background, and tempered with about 25 years of operating experience at other tidal flood control structures in all kinds of weather, it is necessary that any new residential, commercial or industrial developments bordering the tidal estuary have first floor elevations not less than +9.0 feet NGVD and minimum lot elevations not less than +8.5 feet.

Revere Beach Features - Features along Revere Beach are shown in the Main Report and include 3920 feet of structures. Heights of protection are shown on Table 5.

The existing walls and beach along Revere Beach from Eliot Circle to Carey Circle must be maintained to assure no future erosion of the beach and overtopping in Reaches A and C, or increased overtopping in B and D.

. Reach K - A tide gate on Sales Creek, Plate 20, is required where it passes under Revere Beach Parkway to protect the Crescent Beach or Garfield School area against flooding from tides reaching EL. 10.3, currently a 100 year event. Higher tides than EL. 10.3 flooding Sales Creek would begin to flow over Revere Beach Parkway. Walls or dikes to prevent flows over the parkway are not economically justified compared to damages prevented. This economic comparison is shown later in "Optimization of the Project".

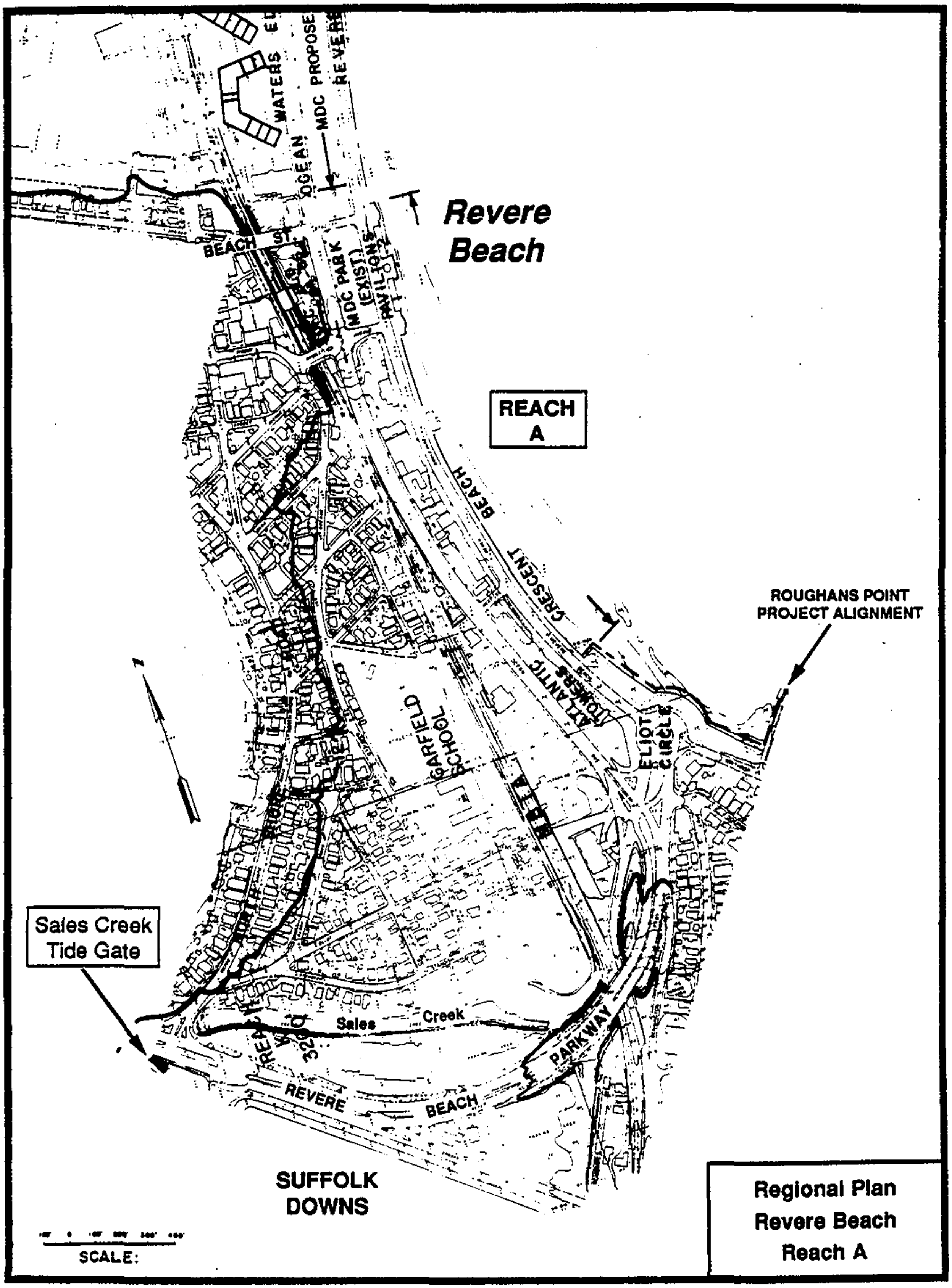

Revere Beach
REACH A
BEACH ST.
MDC PARK (EXIST.)
PAVILIONS
OCEAN
WATERS
MDC PROPOSE
BEACH
CRESCENT
ATLANTIC TOWERS
ELIOT CIRCLE
GARFIELD SCHOOL
ROUGHANS POINT PROJECT ALIGNMENT
Sales Creek Tide Gate
Sales Creek
PARKWAY
REVERE BEACH
SUFFOLK DOWNS
SCALE:
Regional Plan
Revere Beach
Reach A

PLATE 20

. MBTA Closure - Tides exceeding EL. 10.3, although rare, would flood the Garfield School area. To prevent flooding from extending into the Ocean Avenue and Wonderland areas, a "Temporary closure" 40 feet wide would be required across the MBTA Blue Line tracks as they pass under Shirley Avenue or Beach Street, Plate 21. The tracks are between EL. 7 to 8 while the 500 year and SPN flood levels in the Garfield School area are about EL.8.6 and EL.10, respectively. The closure would need to be at least two to three feet high for these events. An additional two to three feet of bags should be available for the freeboard range. A more permanent type gate closure would be considered in design.

. Park Dike - Extensive overtopping occurs over the seawall in Reach B from north of the Beach Street Pavilion to and including the Revere Street South Pavilion #5 due to the eroded condition of the beach. Alternatives investigated for the Revere Beach Backshore LPP to reduce overtopping were: raising the vacant park land behind the wall, breakwaters 500 feet in front of the wall, an armor stone revetment in front of the wall, raising the existing wall, and widening the beach beyond that designed for the authorized Beach Erosion Control Project.

The most economically feasible and acceptable option was raising the parkland behind the wall. Reaches B5 and B7 are vacant parkland from Beach St. to Revere St., bounded by Ocean Avenue and Revere Beach boulevard, except for the MDC Police Station and bath house. The Master Plan for the Reservation also includes raising the parkland. This feature called the Park Dike would be constructed high enough so that water overtopping the existing seawall would flow back out over the wall. Also included is a ramp on the Boulevard at the south end of the dike and raising the Revere Street intersection at the north end to contain the water. Retaining walls would be built to tie the dike into each side of the police station. At the north side of the station, a ramp would pass over the dike for police access. Landscaping with tree replacement, lawn and shrubs is included. There are 8.5 acres of vacant land which would be used for this Federal project and is owned by the MDC.

. Reach D Ponding Area - There is no problem with overtopping along most of Reach C, Plate 22. At the north end of Reach C, a 300 foot stretch of beach has eroded probably due to erosion at the adjacent 1500 feet of concrete steps in Reach D1, Plate 23. Both areas were overtopped in 1978 and rather than raise the walls higher, a storage area behind the homes along the boulevard can be protected to store the water.

The existing ponding area behind the homes along Revere Beach Boulevard (Reach D) provides natural storage for drainage in the area. Overtopping from the beach seawall also flows into this storage area. If the capacity of the storage area is exceeded due to extreme overtopping of the seawall, water would then flow freely over North Shore Road and into the Pines River. The floodgates would control the height of the Pines River at about two feet below the road surface during coastal storms.

The total ponding area is about 20 acres, located between North Shore Road and the embankment to the Revere Beach Boulevard. It extends 3600 feet from near Carey Circle southwest to the old narrow gage railroad embankment behind Seaview Condominiums. The major portion of the storage area is salt water wetlands along the Eastern Mass Electric Co. right-of-way. Existing state and Federal laws can be used to protect this ponding area.

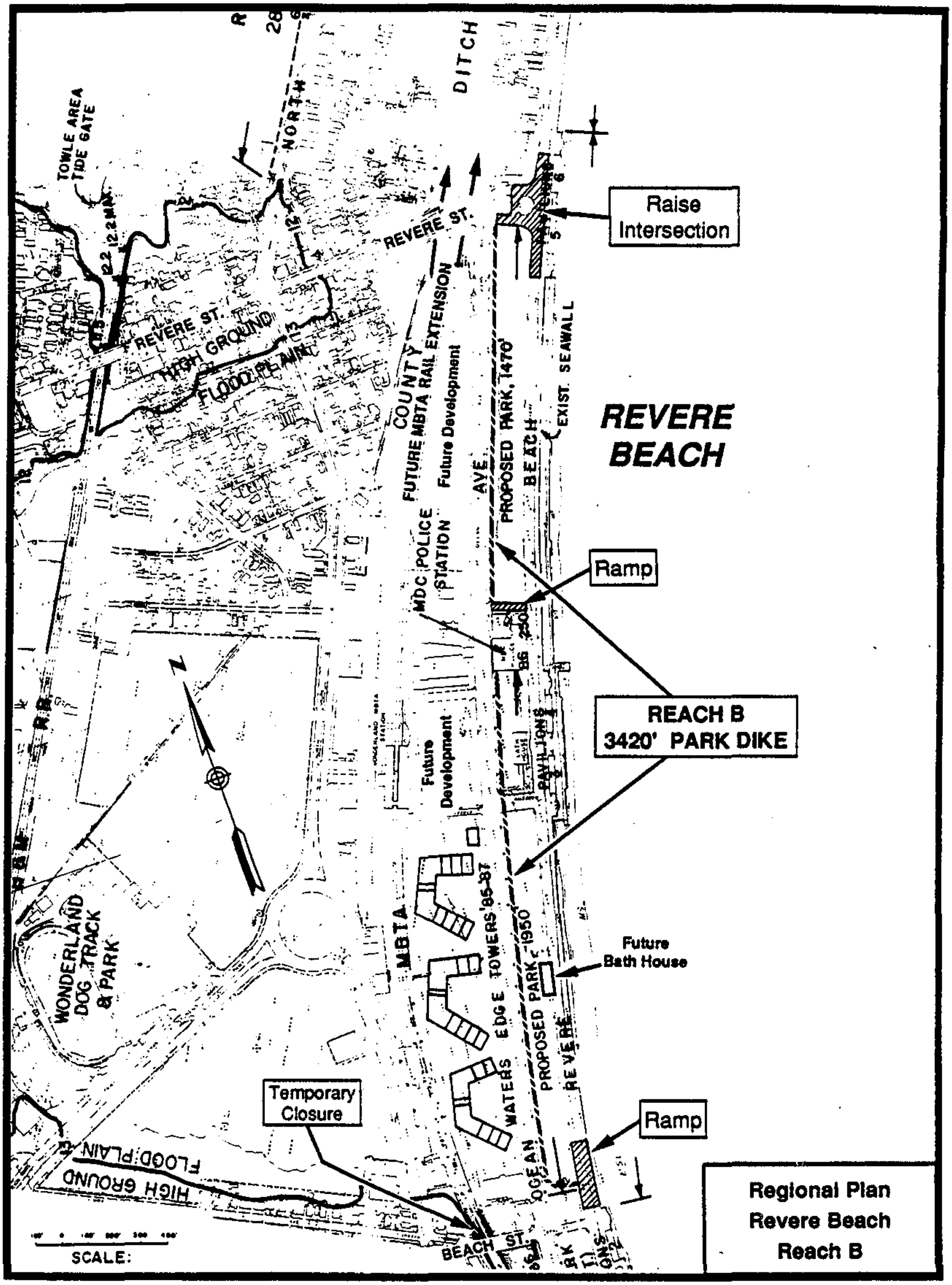

Raise
Intersection
REVERE
BEACH
Ramp
REACH B
3420' PARK DIKE
Future
Bath House
Temporary
Closure
Ramp
Regional Plan
Revere Beach
Reach B
TOWLE AREA
TIDE GATE
REVERE ST.
HIGH GROUND
FLOOD PLAIN
DITCH
COUNTY
FUTURE MBTA RAIL EXTENSION
Future Development
AVE.
PROPOSED PARK, 1470'
BEACH
EXIST. SEAWALL
MDC POLICE
STATION
PAVILIONS
Future
Development
MBTA
WATERS EDGE TOWERS '85-'87
PROPOSED PARK, 1950'
REVERE
OCEAN
WONDERLAND
DOG TRACK
& PARK
FLOOD PLAIN
HIGH GROUND
BEACH ST.
SCALE:

PLATE 21

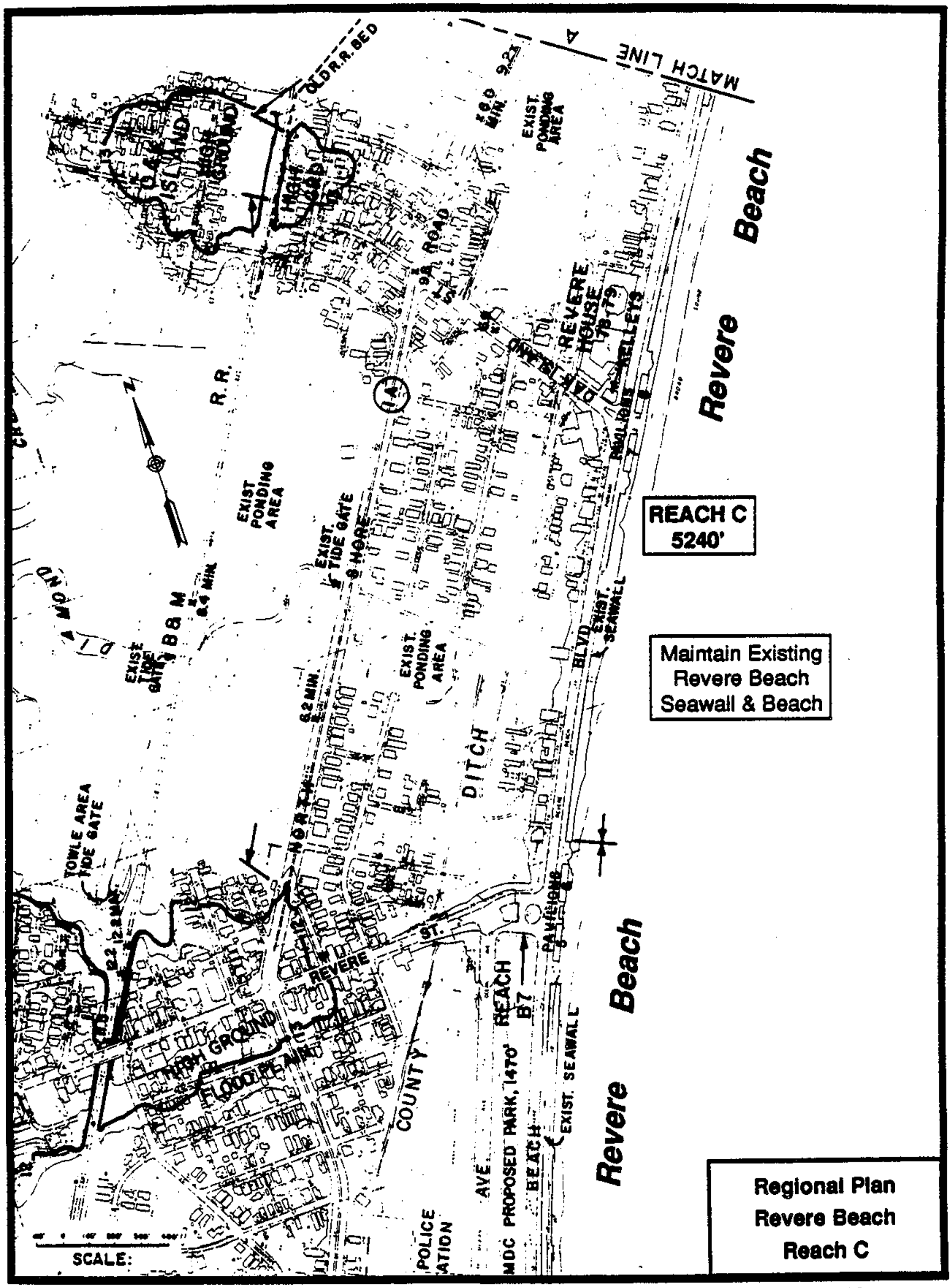
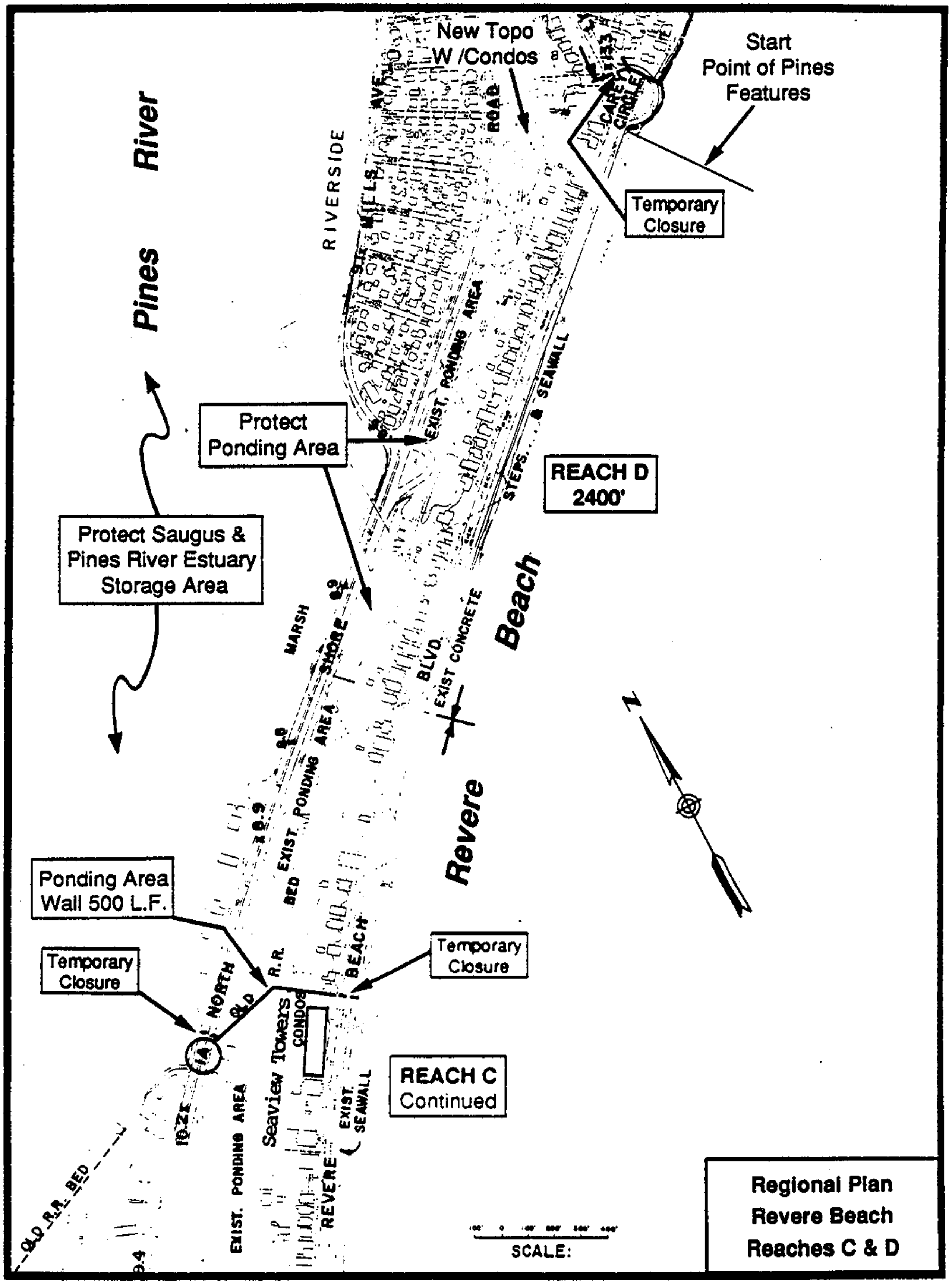

REACH C
5240'
Maintain Existing
Revere Beach
Seawall & Beach
Regional Plan
Revere Beach
Reach C
Revere Beach
Revere Beach
MATCH LINE
REACH B7
EXIST. PONDING AREA
EXIST. TIDE GATE
TOWLE AREA TIDE GATE
HIGH GROUND
FLOOD PLAIN
REVERE ST.
COUNTY
DITCH
NORTH
R.R.
EXIST. SEAWALL
MDC PROPOSED PARK, 1470'
SCALE:

PLATE 22



Regional Plan
Revere Beach
Reaches C & D

PLATE 23

A 500 foot long concrete wall located along Reach "M" would be required along the top of the old narrow gage embankment to contain the ponding area. The wall would extend to the Boulevard sidewalk along the north side of the Seaview Condo driveway with possibly capping rather than replacing the existing retaining wall. About a two to three foot high sandbag closure to the seawall would help to assure water flows down to the ponding area and not along the Boulevard. A similar closure would also be used at Carey Circle to direct the water. In design, gated closures will be considered.

<u>Park Dike - Parkland Fill vs. Drainage</u>

The construction of the Park Dike above <u>without</u> the additional random fill from the top of the dike sloping gradually toward the Bouleard would leave a gully. The gully would trap water running off both the dike and the embankment up to the Boulevard. The additional random fill to create the parkland directs the water to runoff into the Boulevard drainage system.

Without the additional random fill, a drainage system would be needed in the gully running along the ocean side of the dike to collect the runoff and carry it to the County Ditch. In addition, sluce gate closures would be required, which would be closed when water overtops the seawall and ponds against the dike.

The cost of random fill (and sidewalk replacement) would naturally drain the area and cost about $500,000. The drainage system, however, would cost about $1,800,000. The random fill for drainage and parkland is not only less expensive than a drainage system, but also provides recreation benefits.

(FOR FLOODGATE ALIGNMENTS 1 AND 2 ONLY)

<u>Point of Pines Features</u> - The original Point of Pines Local Protection Project was approved by the Chief of Engineers in the Detailed Project Report (DPR), dated October 1984. Due to the inability of the City of Revere to finance the non-Federal share of Project First Costs, design of the project was discontinued. Mayor Colella of Revere in a letter dated June 10, 1988 advised the Corps the City was "unable to commit to the funds necessary to bear the local cost sharing of the project." (Point of Pines LPP)

Mayor Colella's letter further advised that combining the Point of Pines project with the Selected Plan "...would be strongly supported by this office...The city of Revere will pursue funding assistance from the State and request the State sponsor of the Selected Plan to share the costs in an effort to off-set the impacts associated with siting the regional floodgate structure adjacent to the Point of Pines."

Tieing into the Point of Pines LPP project had been included as a requirement with Floodgate Alignments #1 and #2. Since the LPP was not likely to be built it was then necessary to include Point of Pines features into the Plan to protect the integrity of the Regional Plan for Floodgate alignments 1 and 2.

. <u>Formulation Criteria</u> - The Regional Plan was formulated to tie into the Point of Pines shorefront provided the shorefront is stabilized and would not fail to the point the free flow of the ocean or excessive overtopping would endanger the structural integrity or benefits afforded by the Regional Plan, Plate 24. Also the shorefront should not fail for the Regional Project's design storm.

In other words, if the existing shorefront protection (sand dunes, walls or stoned faced embankment) at Point of Pines were to fail such that the stillwater level of the ocean were to pour in, this would result in tremendous volumes of water outflanking the floodgate structure and likely causing serious loss of protection to the area protected by the Regional Plan. This cannot be allowed to happen.

. <u>Analysis of POP's Shorefront</u> -

<u>Reach A</u>: Existing Revere Beach seawall at Carey Circle, Plate 24. Overtopping (O.T.) here affects others besides Point of Pines. The wall is subject to severe storm and daily wave action. A revetment is needed to (1) reduce overtopping and also for (2) stabilizing the wall, which is currently severely deteriorating at the base along the front surface. The overtopping (O.T.) analysis used a top of existing wall at EL. 16.5. Failure of the wall would result in the ground as the top elevation at EL.12, barely above the 100 year D.S.W.L. (EL.10.3). Overtopping would significantly increase if this wall failed. A replacement wall is more expensive than a revetment and at the same elevation does not reduce overtopping. The wall would need to be raised over 10 feet. A revetment with a top elevation at EL.13.2 transitions to EL.16 to meet with Reach B, and a slope of 1:3 must be provided to stabilize the wall and reduce overtopping which floods Point of Pines and other areas.

<u>Reach F</u>: This existing precast wall with a Top Elevation of 12 to 12.9 is along the Saugus River from the dunes to the floodgates. The wall must be raised to three feet above the design stillwater level (D.S.W.L.) near the gates and two feet away from the gates for uncertainty in water levels from wave action near the gates. Also, the 2 to 3 feet above D.S.W.L. prevents additional wave overtopping. We must assure conditions would not be made worse. The existing wall foundation is exposed and stability is questionable. The ground is between EL.8.5-9 behind the wall and below the D.S.W.L.'s. A new stable wall is therefore required.

<u>Reach E</u>: The sand dunes are assumed to fail above the 1978, 100 year event due to the deficiency in the "state-of-the-art" during planning to analyze their stability for events which have not yet happened. Since structures should not fail if the design event is exceeded, the dunes would be backed up by a wall or revetment for all three design events. The top elevation should prevent any significant increase in overtopping. Thus design a wall or revetment near the top of the runup. Also, the dunes would be replaced and protected to help prevent beach erosion resulting in higher rates of overtopping and the need for a larger and higher structure. The top elevation of the dunes range from 12 or less in breached paths to a high of 16 and should be replaced no lower than existing top elevations or above the revetments enough to support dune grass.

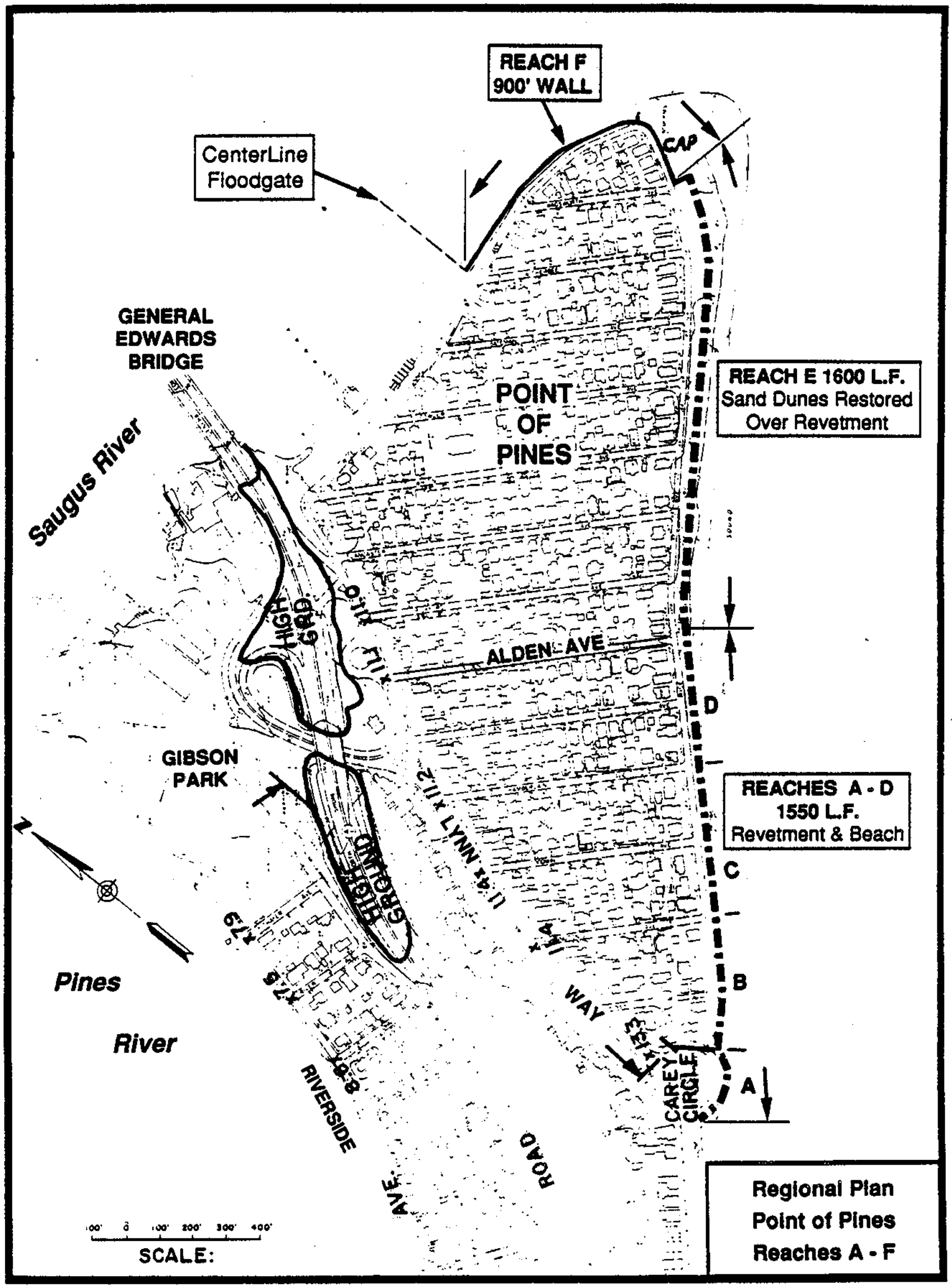

REACH F
900' WALL
CenterLine
Floodgate
CAP
GENERAL
EDWARDS
BRIDGE
POINT
OF
PINES
REACH E 1600 L.F.
Sand Dunes Restored
Over Revetment
Saugus River
HIGH
GRD.
ALDEN AVE
D
GIBSON
PARK
REACHES A - D
1550 L.F.
Revetment & Beach
LYNN
HIGH
GROUND
C
B
Pines
River
WAY
CAREY
CIRCLE
A
RIVERSIDE
AVE.
ROAD
SCALE:
Regional Plan
Point of Pines
Reaches A - F

PLATE 24

Based on revised wave heights, the top of runup on a 3 on 1 sloped revetment for D.S.W.L.'s EL.10.3, 11.2 and 12 are shown below. The DPR report showed a steeper 2 on 1 sloped revetment increases the height of runup higher than existing runup in Reaches B, C, D and E. In order to prevent making conditions worse, a 1:3 sloped revetment would be used in Reaches B, C, D and E, if required, to stabilize the shorefront.

		Design Stillwater Level (D.S.W.L.)		
Reach	Length	100 yr (EL.10.3)	500 yr (EL.11.2)	SPN (EL.12)
		1:3 Slope Top of Runup - EL. (Ft. NGVD)		
E	1600'	12.9	14.7	15.6
Reach		TOP OF REVETMENT AT 1:3 SLOPE		
E		13.0	15.0	16.0

Reach D - a concrete cast in place wall to EL.15.4. The beach is at EL.6.5 to 11, average 9±. Assume the base of wall is at EL.3. The wall was stable for the 1978-100 year storm but could fail for higher storms. No as-built drawings are available on its foundation. So as not to fail for 500 year and SPN events, provide toe protection to stabilize the wall and prevent free flow of the ocean in to the area. The ground also varies from EL.10.3- 11.5 behind the wall which is near the 100 year DSWL. A revetment to protect the toe of the wall from scouring out is needed with a top about EL.14.5 and 1 on 3 slope. The top of revetment is needed at about EL.14.5 due to the 13 foot thickness of the rock layers which should start close to the bottom of the wall.

Reach C: In 1978 the wall was undermined, rocks supporting the wall moved onto the beach, all fines and the apron behind the wall washed out and water poured through underneath and over the wall, per residents. The wall is unstable and the foundation was undermined in 1978 and would again for similar or rarer storms.

The EL.16.4 wall resting on about a 1 on 1 sloped rock foundation needs to be stabilized to prevent failure and extensive increases in overtopping and erosion of material. The revetment would be similar to the DPR due to unstable foundation conditions and, if O.T. occurs, erosion behind the wall could also cause the wall to fail. Also, the ground (EL.12) behind the wall is barely high enough to prevent free flow at the 100 year event. If the road erodes then free flow would accelerate in this reach.

For the 100 year and higher events it will likely fail again. A revetment is needed to EL.16 top and 1 on 3 slope to prevent wall failure resulting in excessive overtopping or free flow of the ocean.

Reach B consists of a variety of structures protected by or consisting of rock protection with about a 1 on 1 slope.

Reach B needs to be rebuilt as underlayer and rock along the slope and at the top both washed out in 1978. Rocks rolled toward the homes in '72 losing the top 3 feet of the rip rap. The top elevation of all existing structures in this reach are dependent on existing rock protection.

To stabilize the concrete and asphalt walls and rip rap heights and slopes in this reach, a revetment is needed. Failure of the existing shorefront structure is expected again. As a result, existing top elevations of the shorefront could drop as follows:

Reach	Existing Top Elev.	Top EL. After Failure (Ft. NGVD)
B	Range from 14.7 to 15.9	11.9 to 13.2

Considerable overtopping into Point of Pines occurs in Reach B since the beach is eroded and higher waves and run-up occurs. A revetment to stabilize this shorefront is required with a top elevation of 15.9 minimum, say 16, and a 1 on 3 slope.

. Summary - For all Reaches A to E a stabilizing revetment and a new wall in Reach F are needed and would be designed so as not to fail if overtopped by an SPN. Therefore, the sizing of the rock protection would be designed the same as the sections in the Detailed Project Report, with a 1 on 3 slope with the top of revetment elevations as shown below.

The benefits to stabilizing the shorefront with the Regional Plan include:

(1) reduction of the replacement and maintenance costs of the existing shorefront structures,
(2) reduction in flooding from the 1 on 3 revetments and
(3) stabilization of the shorefront to protect the integrity of the Regional Plan.

	MINIMUM TO STABILIZE SHOREFRONT WITH 3 ON 1 REVETMENT TOP ELEVATION (Ft. NGVD)
Reach A	EL.13.2
B	EL.16
C	EL.16
D	EL.14.5
E 1-3	EL.13.0 to 16.0 (100-SPN)
	TOP OF WALL (Ft. NGVD)
F	3 ft. above the D.S.W.L. (used to design floodgates along river and 2 ft. behind dunes.)

. Design Top of Structures at Point of Pines - In Reaches A, E & F a Revetment or wall is required as described for the Regional Plan stabilization.

The analysis used revetment top EL.'s within a foot of the top of runup at Reaches B and C as shown in Table 21.

There is no significant overtopping of the Reach D wall with a 1:3 top of the revetment up to about the 500 year event. Only the "stabilizing" revetment is required up to the 500 yr. design level, since the volume of water in the top 2-3 feet of run up is negligeable.

For the SPN top elevations needed in Reaches B, C and D, the elevation shown would significantly reduce the overtopping.

TABLE 21

STRUCTURE HEIGHTS AT POINT OF PINES

FOR OPTIMIZATION USING A 3 ON 1 REVETMENT

Plan:	10 yr.	100 yr.		500 yr.		SPN	
DSWL:	(9.2)	(10.3)		(11.2)		(12.0)	
Reach	Minimum Top Revet.	Top Revet.	Top Runup	Top Revet.	Top Runup	Top Revet.	Top Runup
B Existing Rip Rap Max @ EL.15.9, Wall at EL.15.4	15	16	16.8	18.0	17.7	18.5	18.5
C Existing Wall top at EL.16	15	16	15.3	16.5	16.2	17.0	17.0
D Existing Wall at EL.15.4	14.5	14.5	15.3	16.5	16.2	17.0	17.0
Summary for:							
E Dunes*	12.0	13.0	12.9	15.0	14.7	16.0	15.6

F Use Floodgate DSWL plus 3 feet along River wall and 2 feet for wall cap near dunes.

* Revetment under dunes should be at least 2 feet above the DSWL of the Floodgates.

. Point of Pines Structural Shorefront Features Summary - 100 Year Plan(See Plate 24) -

Reach A - 230 feet. The revetment proposed for the Carey Circle seawall is also a feature for improvements along Revere Beach to stabilize the wall and reduce overtopping in several parts of Revere, as previously explained.

Reach B - 440 feet. The required armor stone revetment with a minimum top elevation of 16 ft. NGVD, 10 foot berm, sloping one on three to the existing beach required for 100 year protection. It would reduce significant damages at the recurring 1978 flood levels, but not for rarer events.

Reach C - 430 feet. Same armor stone revetment required in Reach B.

Reach D - 450 feet. The armor stone revetment top elevation would transition from a minimum EL.16 at the beginning of Reach D and reach a minimum EL.14.5 at the end of Reach D.

Reach E - The sand dunes (1720) would be restored to a top elevation above the revetments with crossovers at the end of each street, dune grass and fences to protect the dunes as with the approved LPP project; also, Reach E -1600 feet. An armor stone revetment under the dunes would be required to assure that, if the dunes are breached, the stillwater level of the ocean would be stopped by a revetment with a top elevation of 14.0 minimum.

Reach F - 900 feet. A 700 foot concrete wall would be constructed with a top EL. of three feet above the Floodgates design still water level, that is a top elevation of 13.3, 14.2 and 15.0 for stillwater levels of EL. 10.3, 11.2 and 12.0, respectively. This reach ties into the Floodgate structure and into a 200 foot existing wall behind the dunes (Reach E) which would be capped to two feet above the D.S.W.L. and tie into the revetments.

. Other Features -

Beaches - The beach fronting Reaches B to E, would be built up using sand excavated from the dunes since it is less expensive to use it on the beach than haul it away. The beach helps protect the structural integrity of the revetments and sand dunes. Sand dredged from the Saugus River might be used at Point of Pines (if "acceptable" and reusable material is available), and reduce the Project Cost for hauling to a disposal area. Surface samples of the river and Lynn Harbor excavation areas show less than 15% fines. Additional sampling including sub-surface borings would be accomplished during the design stage to determine the reusable quantities suitable for beach use, if any.

Site Restoration - Site restoration near the floodgate structure and other project features at the Point of Pines neighborhood along project features would include:

(a) Site restoration behind the revetments along Rice Ave. with granite curbs, grass and shrubs. The curbs would prevent vehicle damage to revetments and dunes.

(b) Removal of the remaining Reach F wall (about 270 feet) between the floodgates to the Pump House for access during construction would be replaced with a curb at the edge of the grass (top at EL. 10±) and beach (at EL 9±). See Plate 25.

(c) Provide a vehicular gate in Reach F for entrance to the beach for access to the floodgate dike and beach cleaning.

(d) Walkways over the dunes to protect them at the end of each street and replacement of crossovers of walls and revetments are also included for the end of streets.

LYNN HARBOR FEATURES - Feature alignments required in Lynn for the plan are shown on Plates 26 and 27. The top elevations for the proposed structures were previously shown on Table 16.

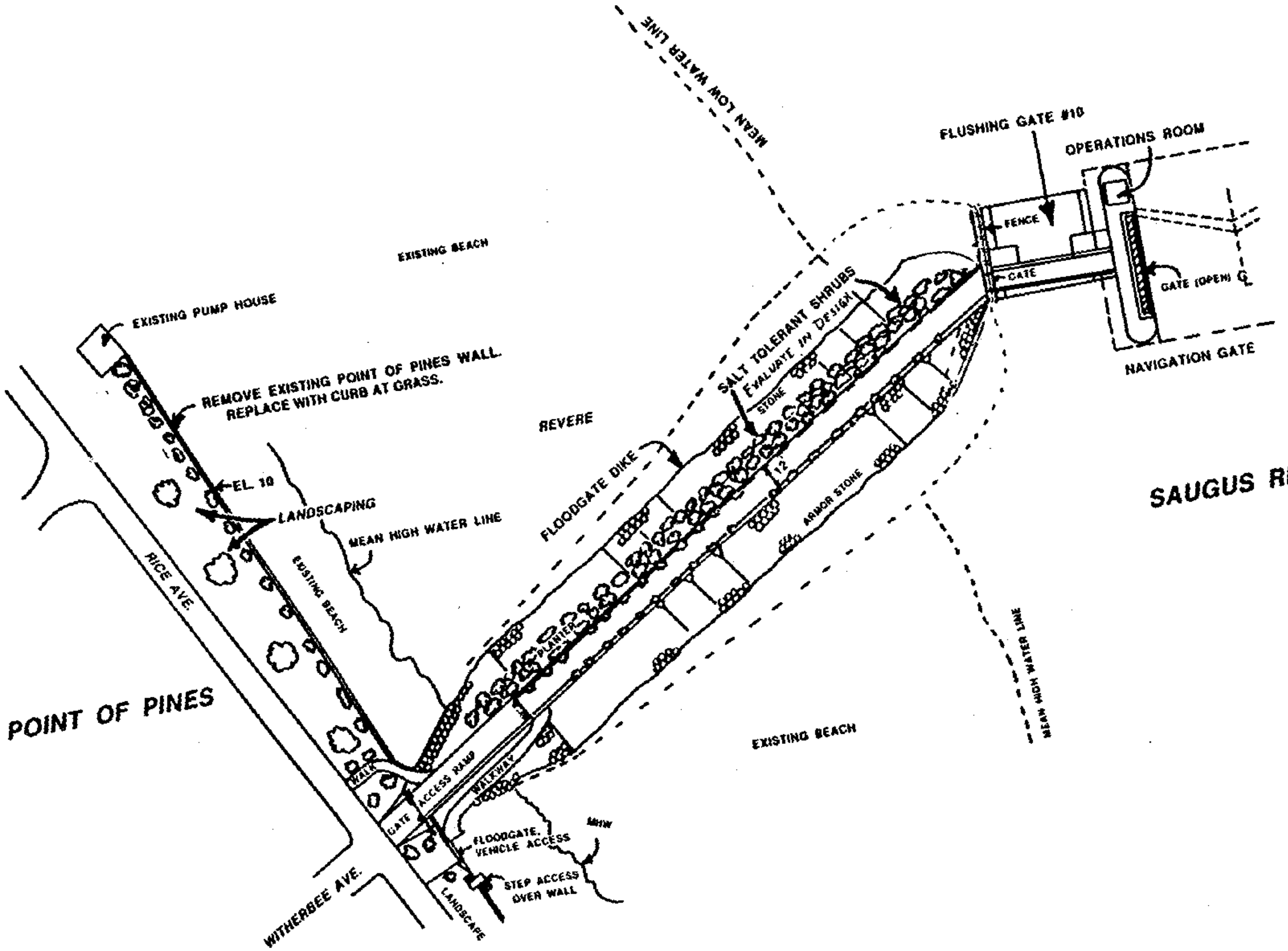

MEAN LOW WATER LINE
FLUSHING GATE #10
OPERATIONS ROOM
FENCE
GATE
GATE (OPEN)
NAVIGATION GATE
EXISTING BEACH
EXISTING PUMP HOUSE
REMOVE EXISTING POINT OF PINES WALL.
REPLACE WITH CURB AT GRASS.
REVERE
SALT TOLERANT SHRUBS
EVALUATE IN DESIGN
STONE
FLOODGATE DIKE
EL. 10
LANDSCAPING
MEAN HIGH WATER LINE
SAUGUS RIVER
ARMOR STONE
12
PLANTER
EXISTING BEACH
RICE AVE.
POINT OF PINES
MEAN HIGH WATER LINE
EXISTING BEACH
WALK
ACCESS RAMP
WALKWAY
GATE
FLOODGATE,
VEHICLE ACCESS
MHW
STEP ACCESS
OVER WALL
LANDSCAPE
WITHERBEE AVE.

PLATE 25

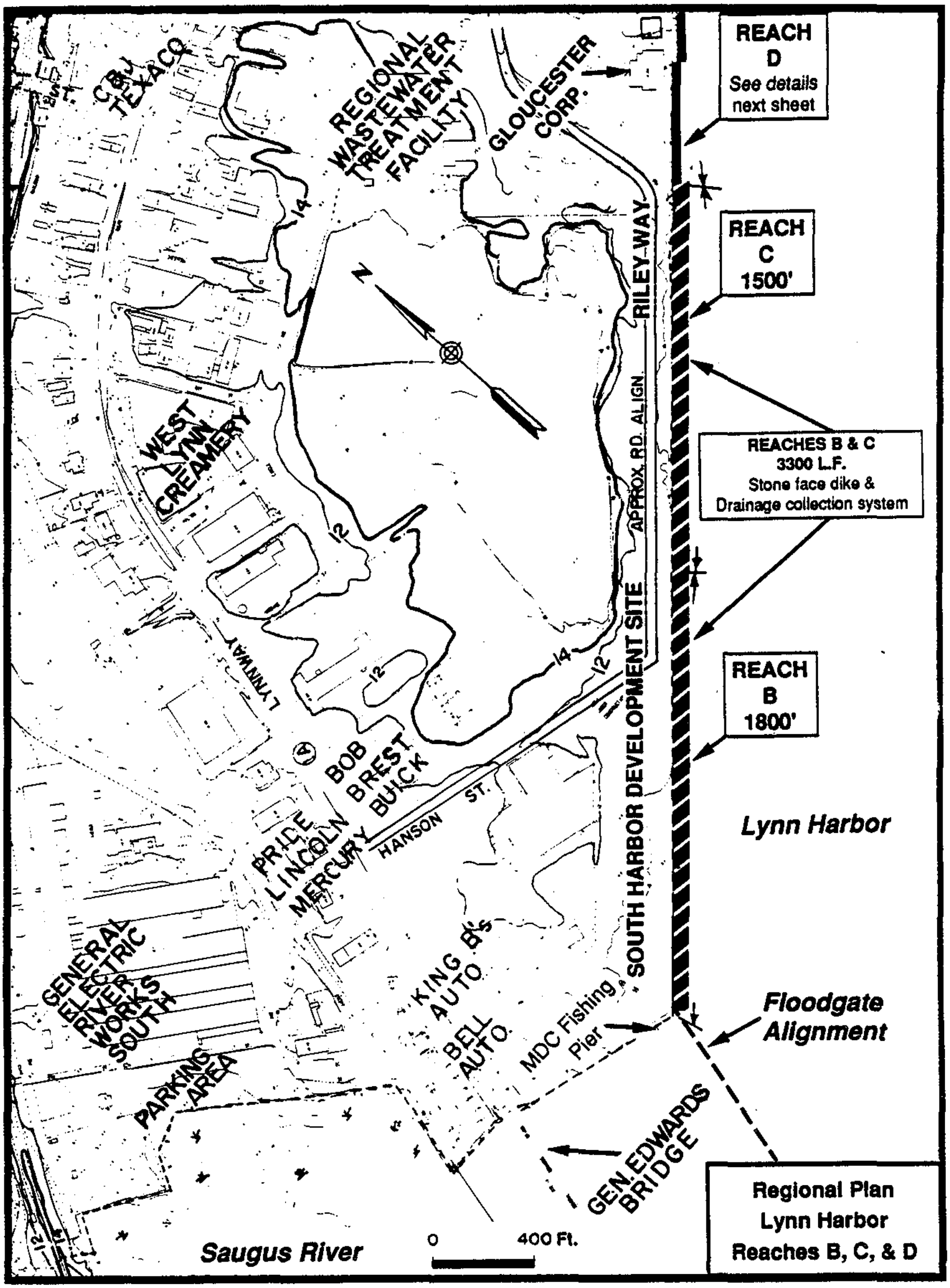
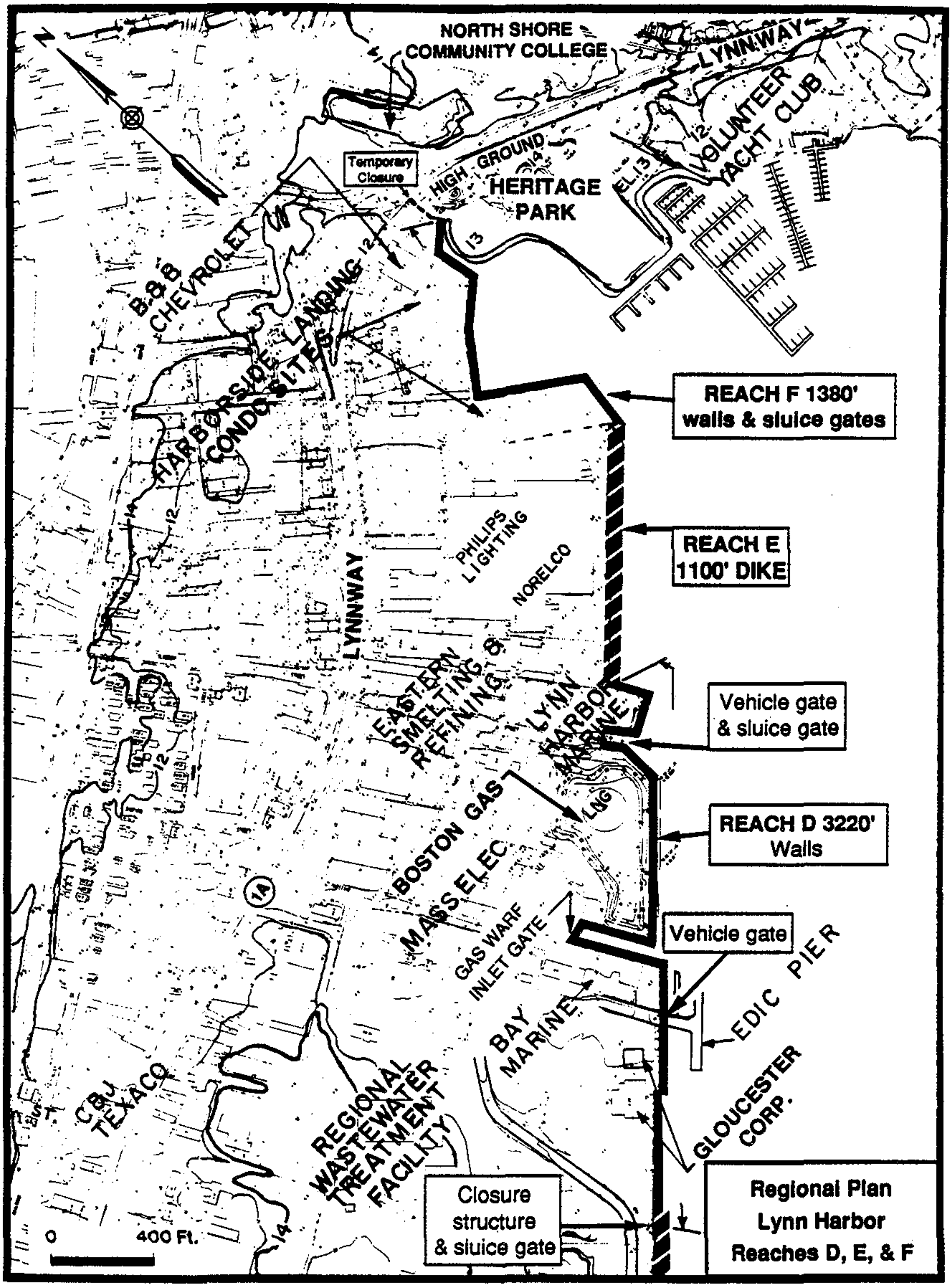

REACH D
See details next sheet
REACH C
1500'
REACHES B & C
3300 L.F.
Stone face dike &
Drainage collection system
REACH B
1800'
Lynn Harbor
Floodgate Alignment
Regional Plan
Lynn Harbor
Reaches B, C, & D
CBJ TEXACO
REGIONAL WASTEWATER TREATMENT FACILITY
GLOUCESTER CORP.
RILEY WAY
APPROX. RD. ALIGN.
WEST LYNN CREAMERY
LYNNWAY
BOB BREST BUICK
PRICE LINCOLN MERCURY
HANSON ST.
SOUTH HARBOR DEVELOPMENT SITE
GENERAL ELECTRIC RIVER WORKS SOUTH
KING B's AUTO
BELL AUTO
MDC Fishing Pier
PARKING AREA
GEN. EDWARDS BRIDGE
Saugus River
0
400 Ft.

PLATE 26



NORTH SHORE COMMUNITY COLLEGE
LYNNWAY
VOLUNTEER YACHT CLUB
Temporary Closure
HIGH GROUND
HERITAGE PARK
EL.13
B & B CHEVROLET
HARBORSIDE LANDING CONDO SITES
REACH F 1380'
walls & sluice gates
PHILIPS LIGHTING
NORELCO
LYNNWAY
REACH E
1100' DIKE
EASTERN SMELTING & REFINING
LYNN HARBOR MARINE
Vehicle gate
& sluice gate
BOSTON GAS
LNG
REACH D 3220'
Walls
MASS ELEC
GAS WARF INLET GATE
Vehicle gate
EDIC PIER
1A
BAY MARINE
GLOUCESTER CORP.
CBJ TEXACO
REGIONAL WASTEWATER TREATMENT FACILITY
Closure
structure
& sluice gate
0
400 Ft.
Regional Plan
Lynn Harbor
Reaches D, E, & F

PLATE 27

. <u>Reaches B & C</u> - Along Lynn Harbor reaches A, B, C and F1 are the TransContinental Development Corporation proposed plans to develop the South Harbor and Inner Harbor areas. Along the shorefront, the Corps plans include a dike with sloping rock protection as TransContinental had completed at Heritage Park and proposed for their other plans.

South Harbor Development in the vacant land behind Reaches A to C includes a $700 million initial proposal, on about 50 acres with 800 condominium apartments in five-six high-rise buildings, a 350 room hotel and eight high-rise office buildings and a 250 slip marina. The project would be developed in phases over 10 to 20 years.

The existing protection along Reaches B and C include a timber bulkhead built in the 1930's to contain dredge material. The bulkhead is deteriorated and much of it in Reach C is totally gone with bank protected by rip rap and debris. The top elevation of the bulkhead varies from EL.10.8 to 11.7 ft. NGVD and rises about 13 feet above sand flats at about EL.-2. In Reach C where the bulkhead is gone the rip rap (1:4 slope±) slopes up to the road (EL.10.3-12). The design top elevations for improvements along the Lynn Harbor shorefront was based on runup and overtopping analysis using procedures and wave data developed by the Corps Waterways Experiment Station. Also used was information gained from the physical and numerical modeling of overtopping during the design of the Roughans Point project. For Lynn Harbor shorefront revetments and walls top elevations were set very close to the top elevation of the design storms runup. Thus, top elevations shown for the SPN storm would prevent nearly all overtopping. Waves in Lynn Harbor for coastal storms are generally 2 to 3 feet high .

Several alternatives were investigated to reduce overtopping of the shorefront in Reaches B and C including three alternatives.

<u>Alternative #1</u>

A stone face dike located with the back of the dike located at the bulkhead alignment (Previously shown on Plate R8). The dike would almost totally be constructed over several acres of sand flats. This alternative would eliminate any significant impact on development and real estate. This alternative is the recommended one and shown in Figure 9A. Access along the dike would be along the top of dike's road surface (12 feet) and from the waterside. Temporary easements may also be obtained for maintenance since a public right of way is a proposed zoning change for developers along these reaches.

The estimated loss of intertidal sand flats for Reaches B and C are 2.7 and 1.9 Acres, respectively, or a total of 4.6 acres which would need to be mitigated. Proposed mitigation is creating a clam flat in a basin excavated under the I-95 fill. The cost per mitigated acre is about $40,000 per acre. The real estate cost is about $4,500 per acre.

The First Cost of this Alternative follows:
Alternative #1 - Reaches B & C

Construction Cost of dikes with contingency & EDSA (20%):	
Reach B, 1800'	$ 1,940,000
Reach C, 1500'	940,000
Real Estate Perm. Easements	0
Mitigation First Cost:	
Reaches B & C (4.6 Ac @ $40,000/Ac)	184,000
Real Estate Mitig. (4.6 @ $4,500/Ac.Mitig.)	21,000
Alternative #1 Total First Cost	$ 3,085,000

Alternative #2

To reduce impacts on the sand flats, the dikes were evaluated with the toe of dike at the location of the bulkhead so the structure is almost totally over existing land with no significant impact on sand flats but requiring about 4.6 acres of developable real estate. (See Plate Figure 9).

The Real Estate Permanent Easement is about $18.75 per SF or about $817,000 per acre for permanent easements. Temporary easements for all alternatives would be about the same and are not shown. The estimated First Cost for this alternative including adjustments for slightly narrower dikes eliminating 40,000 CY of Dumped Granular Fill, but with 60,000 CY of additional excavated material to dispose of, follows.

Alternative #2 - Reaches B & C

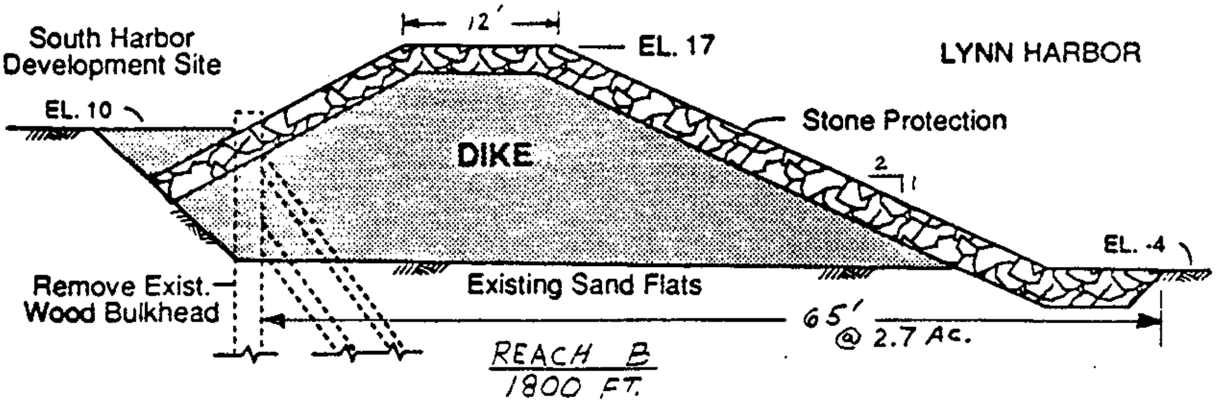
Construction Cost of Dikes with Contingency & EDSA:	
Reach B, 1800'	$ 1,990,000
Reach C, 1500'	1,040,000
Real Estate $4.6 Ac.@ $817 k/Ac.	3,760,000
Mitigation Cost	0
Alternative #2 Total First Cost	$ 6,790,000

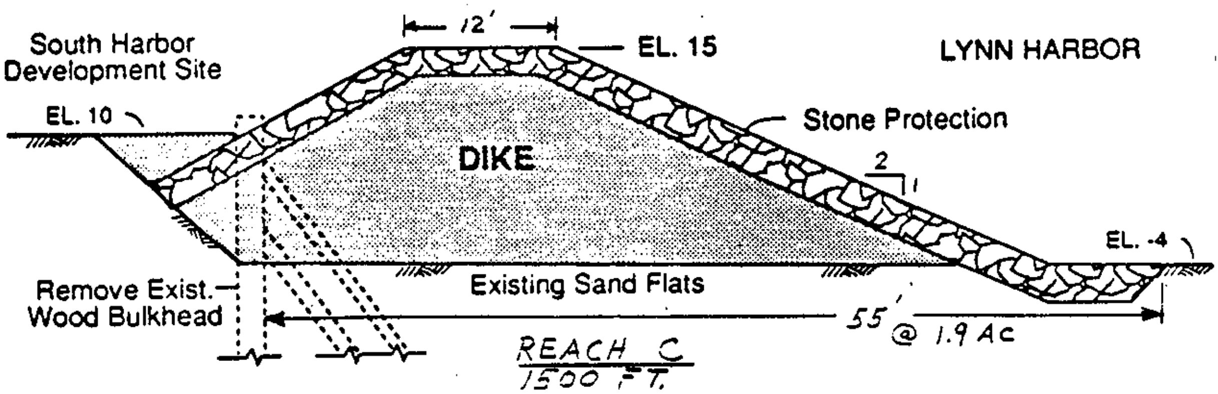
The increased cost over Alt. #1 is $ 3,705,000. The city is currently reviewing zoning requirements to address public access along the bulkhead. Until such time agreements are reached between the city, DEQE and others on the zoning, there is no legal basis for considering a lower real estate value in this area.

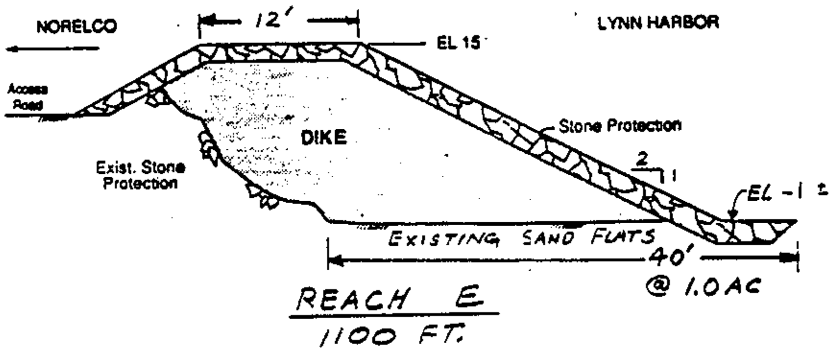
Alternative #3

To reduce impacts on both real estate and sand flats a steel sheetpile wall alternative was also considered. The wall would be built to the ocean side of the existing bulkhead, to be removed. See Figure 10. The steel sheet pile wall would have tie backs which require a 45 foot wide permanent easement, totalling 3.4 Acres. Although the land could still be used for access and stock piling materials in the easement area, the land (Reaches B & C) would be restricted from any permanent construction.

The estimate first cost of alternative #3 follows.

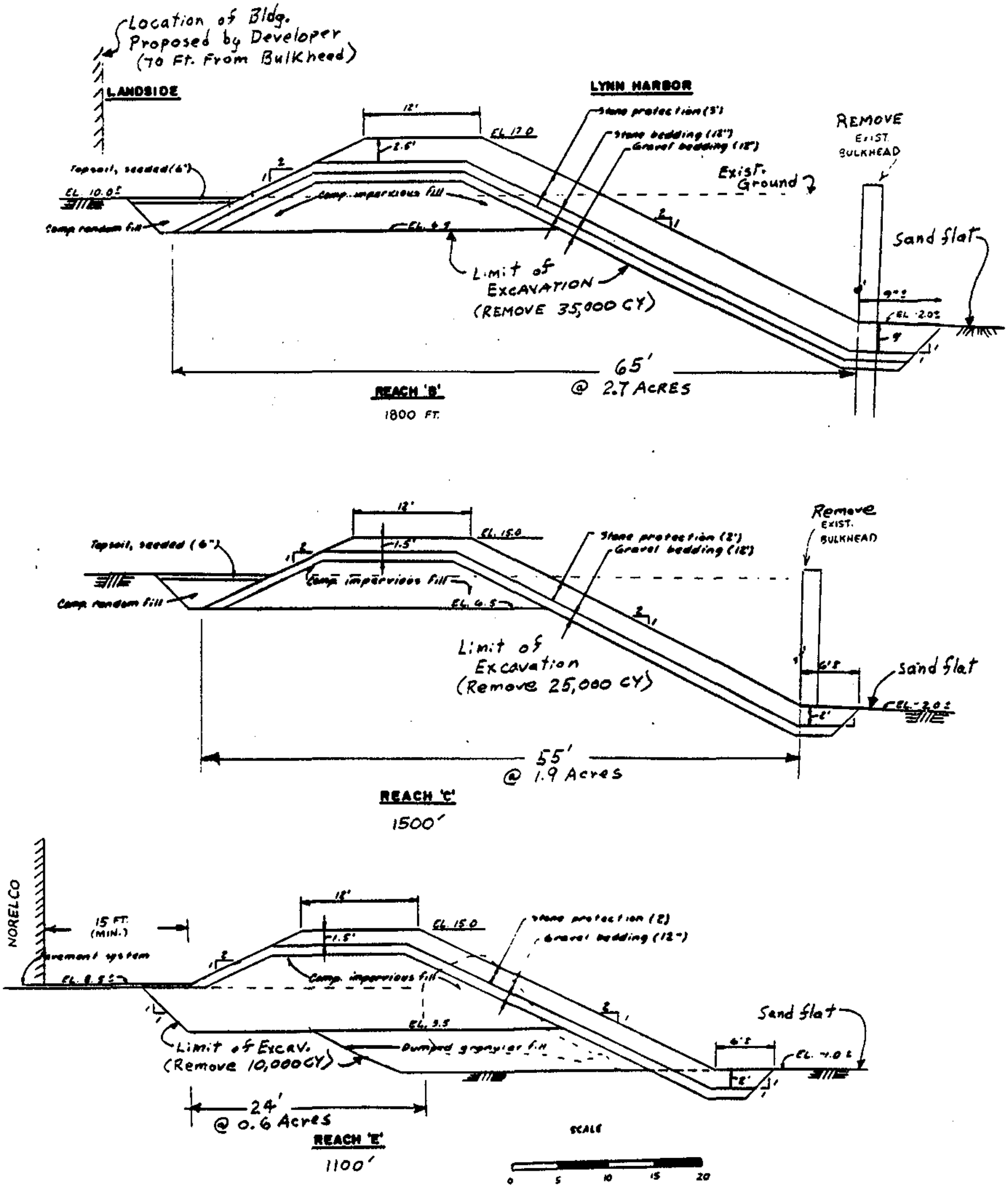






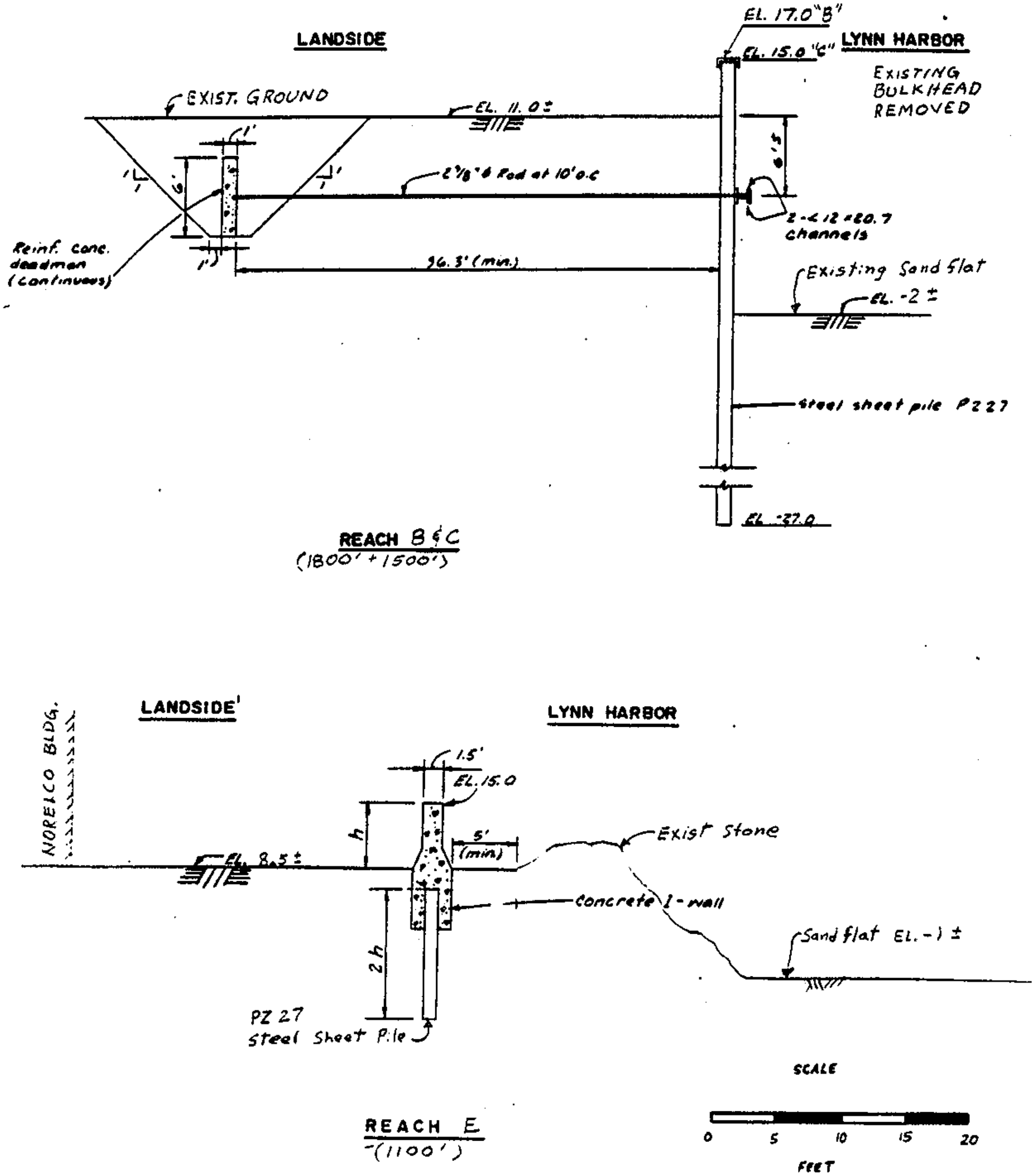
LYNN HARBOR
Alternative #1
DIKES ON SAND FLATS
(Selected)

FIGURE 9A



LYNN HARBOR
Alternative #2
INLAND DIKES

FIGURE 9



LYNN HARBOR
Alternative #3
WALLS

FIGURE 10

Alternative #3 - Reaches B & C

Construction Cost for Walls incl. Contingency & EDSA:

Reach B 1800'	$ 4,400,000
Reach C 1500'	3,560,000
Real Estate 3.4 Ac. @ $817 k/Ac	2,780,000
Alternative #3 First Cost:	$ 10,740,000

The increased cost of Alternative #1 is $ 7,655,000.

. Summary - There is a possibility in the next year or so that the developer would reach a formal agreement on the width of a public access along Reaches B and C, and how the dikes could be constructed. Such a formal agreement may reduce the Real Estate costs for alternatives 2 and 3 and make them more competitive with alternative 1; however no formal agreements have been reached to revise the Real Estate estimate. Alternative #1 is selected since it is the lowest cost alternative, and there are no known overriding reasons to recommend another alternative. See also Reach E.

. Reach D - Reach D is bordered by commercial users of the waterfront and a navigation channel for access to their businesses. Gloucester Fish Corps at the beginning of Reach D has future plans for docking facilities. During design the status of any definite plans may show less wall is needed and the dike in Reach C could extend further along the property. The new city's commercial pier developed by Lynn's Economic Development Office, called the "EDIC Pier" has moorings for vessels adjacent to the wall. At the Gas Wharf Inlet, Bay Marine Inc. uses the inlet for loading and off loading vessels. The navigation channel then passes adjacent to the Boston Gas retaining wall and Lynn Harbor Marine's moorings and boat ramp at the end of Reach D. Access gates are provided: at the EDIC Pier entrance; for Bay Marine's location for lowering/raising boats with a crane at the end of the inlet; and for the Lynn Harbor Marine's ramp. A sluice gate is needed adjacent to the ramp for a storm drain.

Features along this reach include a new steel sheet pile (SSP) wall with tie-backs along Gloucester Fish and EDIC Pier locations to replace existing timber and granite block bulkheads which are deteriorating. In design, depending on soil conditions, real estate impacts and other concerns, alternate types of walls without tie-backs or with shorter tie-backs will be considered.

At the Gas Wharf Inlet the existing PZ 40 SSP wall on the south side would be raised with PZ 40 SSP and a timber platform provided for loading vessels. The wall ties into existing concrete foundation buildings. Along the west and north sides of the inlet with the timber and granite block walls, a new P Z 40 SSP would be constructed. The existing P Z 40 wall fronting the Boston Gas property would be raised with P Z 40 steel. From the end of this wall a SSP wall with concrete cap would be constructed around the Lynn Harbor Marine's shorefront, except for the gate location.

In Reach D, Bay Marine property around the inlet was reviewed with the owner. An inland wall alignment landside of his building was considered but discarded. Problems encountered were interfering with his business;

- . cutting across loading zones;
- . real estate costs;
- . interference with a net work of above ground gas lines at the adjacent Boston Gas property;
- . cutting through the middle of the boat launching property;
- . no protection for these riverward properties; and
- . likely increasing the flooding on the riverward properties since water would pile up as the waves hit the new wall.

At the conclusion of the study, the owner advised the Corps that closing off the inlet with a wall should be considered in design. Significant savings in wall costs are anticipated even with filling in the inlet with random fill.

. Reach E - includes property along Eastern Smelting and Refining and Philips Lighting's Norelco Building. Both managers would like someday to expand to the edge of their property line which is about 150 feet harborside from their existing shoreline. However, due to the extreme difficulty private developers have along the coast in attempting to fill in intertidal sand flats for private use it is highly unlikely that they would be permitted to fill. For this reason and uncertainty in their own planning, the location of the dike was located along their existing shoreline as shown in the Main Report. Three alternatives were considered along this reach.

Alternative #1

Alternative #1 includes the selected dike alignment shown in the Design Appendix with the dike overlapping their existing rip rap and sand flats. The plan results in a loss of 1.0 acres of sandflats which must be mitigated. The following is the First Cost of Alternative 1 (Figure 9A).

Alternative #1 - Reach E

Construction Cost of Dike w/Contingency & EDSA (20%):	
Reach E, 1100'	$ 685,000
Real Estate	0
Mitigation Cost (1.0 Ac. @ $40,000/Ac)	40,000
Real Estate (1.0 Ac. @ $4,500/Ac)	5,000
Alternative #1 First Cost	$ 730,000

Alternative #2

Figure 9 shows the relocation of the dike " Inland" to reduce the impact on sand flats. With the dike a minimum of 15 feet from the Norelco Building, about a 24 foot wide permanent easement is required, for a total 0.6 Acre easement. The loss of sandflats is about 0.3 acres. The dike requires 10,000 CY of additional excavation.

Alternative #2 - Reach E

Construction Cost of Dike w/Contingency & EDSA:	
Reach E, 1100'	$ 835,000
Real Estate (0.6 Ac @ $817 k/Ac)	490,000
Mitigation Cost (0.3 Ac. @ $40,000/Ac)	12,000
Real Estate (0.3 Ac. @ $4,500/Ac)	1,000
Alternative #2 First Cost	$ 1,338,000

The increased cost over Alternative #1 is $ 608,000

Alternative #3

Figure 10 shows the SSP wall with a concrete cap. A 15 foot permanent easement is needed on the land side, 2 feet for the wall and 5 feet on the Harbor side for a total easement area along 1100 feet of 0.6 Acres. There would be no loss of sandflats to mitigate.

Alternative #3 - Reach E

Construction Cost of Dike w/Contingency & EDSA:	
Reach E, 1100'	$ 990,000
Real Estate (0.6 Ac @ $817 k/Ac)	490,000
Mitigation Cost	0
Alternative #3 First Cost	$ 1,480,000

The increased First Cost over Alternative #1 is $ 750,000
Alternative #1 was selected since it is the least cost alternative.

. Reach F - Reach F is divided into two reaches F1 development property and F2 city outfall property. Reach F1's shoreline at EL.8 ft. NGVD is a mix of timber, concrete and rip rap protection. Reach F2 at EL.8-10 is both granite blocks and rip rap. In Reach F1 (1150 feet) the developer has purchased the property and is in the process of developing condominiums and a marina for the proposed Harborside Landing Project opposite the inlet from his Seaport Landing Project and Heritage Park. Harborside property would be filled to EL. 13 ft. NGVD with a rockface on the shorefront. Since the EL. 13 was at the Corps established 500 year level for top of structures in this area, no additional features would be needed. For an SPN design however, a concrete gravity wall would be needed about one foot higher. The developer has stated he plans to build the ground up to EL.18 away from the shorefront. If this occurs, all or part of the wall could be eliminated. The cost of the wall is about $600,000. If the property is not redeveloped, then a dike along the shorefront would cost slightly more than Reach E's Alternative 1 or about $700,000.

. Reach F2 - The 280 feet of shoreline connecting to the Lynn Heritage Park (EL. 13) retaining wall needs to be built up with a wall to house storm drains in this narrow inlet. In this reach are several storm drainage outlets for the city. For costing purposes drains include sluice gates. However, exact drainage requirements will be determined in final design. The new wall would connect with the existing Heritage Park retaining wall at EL.13. At this point a sand bag closure about 100 feet long and a few feet high may be needed to reach the SPN EL.14 contour and median wall (Top EL.16) at Lynnway.

. Reach G - No improvements are needed along the Lynn Heritage and Seaport Landing Property since the ground reaches between EL.13 and EL. 14 along the Lynnway, one to two feet above the SPN stillwater level.

Option #3 Summary of Environmental Impacts

The following summarizes the impacts identified for Option 3, the Regional Floodgate Plan. The Environmental Impact Statement and Report explains the impacts in more detail. The most significant impacts which must be mitigated are the loss of intertidal and subtidal habitat. The location of these impacts for the NED plan, are:

	LOST HABITAT ACREAGE	
	Intertidal	Subtidal
Lynn Harbor Dikes	5.6 Acres	-
Point of Pines Revetments	1.4	-
Floodgate Structure	1.4	0.6 (net loss)
Floodgate Dredged Area	1.0	-
Total	9.4 Acres	0.6 Acres

The loss of 5.6 acres in Lynn harbor for Dikes located on Sand Flats was evaluated against two other alternatives, inland dikes and walls (Table 22). The results, summarized below, show that these alternatives would cost \$4 to \$8 million more, respectively, for the inland dikes and walls. Since there is an acceptable mitigation option for Alternative 1, "dike on sandflats" by creating clam flats with removing the I-95 fill, which would save a significant \$4 million, the Alternative #1 was selected. There are no known overriding reasons to select another alternative. If the city zones the south harbor shorefront for public access in Reaches B and C, the inland dike would warrant further consideration.

Table 22
Lynn Harbor Dike and Wall Alternatives

	Dike on Sandflats (Alt. #1)	Dike Inland (Alt. #2)	Wall (Alt. #3)
Intertidal Sand Flat Lost			
Reach B & C	4.6 Ac.	nil	0
Reach E	1.0 Ac.	0.3	0
Total	5.6	0.3	0
Feature First Cost (In \$1000):			
Reach B & C	\$ 3,085	\$ 6,790	\$10,740
Reach E	730	1,338	1,480
Total	\$ 3,815	\$ 8,128	\$12,220
Increased Cost Over Align. #1:	n/a	\$ 4,313	\$ 8,405

The 1.4 acres of lost intertidal habitat at Point of Pines is unavoidable. The only other alternatives would be to raise walls along the shorefront in Reaches A to D. However, two significant problems result. The walls would need to be raised so high as to be totally

objectionable by the residents. Also additional erosion of the beach and possibly dune area would occur when waves hit the vertical wall surface. Vertical walls were therefore not considered further for these reasons, including the higher cost associated with wall construction. The revetments could not be located inland since the shorefront is bordered by Rice Ave. which accesses homes along the shorefront.

The floodgate structure's caused a loss of 1.4 acres of intertidal habitat. Except for the dike section, the rest of the impact is unavoidable. The dike causes about 0.8 acres of loss. A gravity wall could be used to reduce the loss to about 0.1 acres. However, the additional cost of about 265 feet of gravity wall to replace the dike to the shore is about $4 million.

The additional $4 million is not considered warranted when a reasonable mitigation site exists for the 0.8 acres. The 1.0 acre of lost intertidal habitat from dredging for the floodgate is unavoidable.

- Other Impacts - Other impacts from the Regional Plan include:

- the floodgates would impair the view of about ten homes;
- floodgate construction would cause minor impacts to Point of Pines from noise of compressors and occasional pile driving, as well as, two to three months of trucking along the river reach of Rice Avenue for the dike section.
- the Point of Pines' revetment, dunes, beach and wall would impact the neighborhood for about a year of construction during normal working hours (5 days/week, 8 hrs/day). The wall along the Saugus River would be raised about two to three feet and impair the view from about seven homes;
- the park dike would impair the view from the lobby's of the new high rise condominiums behind it;
- the walls and dikes along Lynn harbor would cause no significant impact to the undeveloped property or commercial property bordering the shorefront. Permanent easements would be required along the stretch of wall between Gloucester Fish and Gas Wharf Inlet. The easement is required for the underground tie-back system for the wall and would prevent any construction within the easement area. The underground tie-backs would not interfere with the existing buildings along the shorefront.

Mitigation - For loss or alteration of about 9.4 acres of intertidal and 0.6 acres of subtidal habitat, the plan is to create 10 acres of intertidal clam flat adjacent to the highly productive Seaplane Basin flats(See Main Report and Design Appendix plates). This would be accomplished by removing the backside of the abandoned I-95 fill to create a basin from about EL.9 to EL.-4 ft. NGVD. The site would be used to create 10 acres of clam flat, a fringe of marsh grass and a seeded 10 foot wide path and a berm around the top of the basin to protect the basin from being breached. About 190,000 cy of material, primarily sand, would be excavated for use in the project, by others, or removed.

It was assumed that during project design that the I-95 fill would be removed down to EL.9 except for the 12 ft. wide berm required for flood reduction on the east side. (Note: The minimum height of this berm should be held to EL.13.5 without the Regional Plan, and EL.11.0 with the Regional Plan. Without the project, the top is set three feet above the 100 Year stillwater level in the estuary, and with the Regional Plan, 3 feet above the maximum estimated estuary water level.) Part of the proposed mitigation area would be lowered by the Corps for the Revere Beach Erosion Control Project, and the rest is assumed removed to EL.9 by others. Of the 190,000 cy, there are 76,000 cy of clean sand between EL.5 and EL.9 ft. NGVD. The project would use about 56,000 cy, and 20,000 cy would temporarily be stockpiled north of the site on the I-95 fill until sold, requiring a temporary easement. About 4000 cy of peat would be removed and hauled to a disposal area.

There would be about 110,000 cy of potentially salty sand below EL.5 which is in the intertidal area. Of this sand, 80,000 cy would be used by the project and 30,000 cy would form a berm around the basin to EL.11 and about 100 feet wide. During design the potential to sell or use additional salty sand would be determined. The 110,000 cy of salty sand could be used for :

(1) Beach replacement at Reaches A and B, Point of Pines (6,000 to 8,000 cy). (Note that of the 36,000 cy of sand excavated for the sand dunes all could be reused at Point of Pines.);
(2) Also, for the project: Random fill (26,000 cy) in Lynn Harbor Dikes and Dumped Granular Fill (46,000 cy).
(3) Possibly sold for road sanding in the winter; or
(4) For Revere Beach and Point of Pines Beach maintenance.

The 76,000 cy of clean sand above EL.5 could be used for:

(1) The Park Dike's compacted random fill (54,000-56,000 cy);
(2) Any of the uses identified for salty sand, or
(3) Sold for general use.

Permanent easements are needed for the basin site and for the salty sand berm around the basin. A temporary easement is needed for storage of clean sand. The clams would be transplanted from nearby clam flats and marsh grass from nearby vegetated marsh.

This was the only practical location and alternative developed for mitigating the 10 acres of lost intertidal and subtidal area. The strong interest in the state and resource agencies to remove the I-95 fill and the lack of better locations resulted in this selection.

An alternate location at the I-95 site for the mitigation site, which would still flush with saltwater by way of the Seaplane Basin, would be immediately east of the proposed site.

Construction Phase 1 Procedures - The mitigation site would start concurrently with the Revere Beach, Point of Pines and Lynn Harbor features. The excavated sand for the mitigation site would be used for other features. Completion of the mitigation site in the first year would also provide several growing seasons during construction to assure the marsh grass and clams are successfully transplanted.

At the Park Dike construction of retaining walls, site preparation and hauling of fill (including sand from the mitigation site) would proceed concurrently. Completion of the park dike would include the rock surface, fill from the top of dike to the MDC's secondary wall at the Boulevard sloped for drainage, and completion of ramps and site restoration.

At Point of Pines construction of the revetments should proceed from Carey Circle and progress toward the dunes. As the dunes are excavated the dune sand should be used to build up the beach fronting Point of Pines Revetment. Excavated dune sand needed to restore the dunes would be stockpiled along side the excavation site until revetments are completed. Construction of the walls at Point of Pines could proceed concurrently with the revetments. Access to the dunes would be by way of temporary two way travel along the river stretch of Rice Avenue.

Along Lynn harbor construction of dikes and I-walls, gravity and PZ40 walls could proceed from several locations. The sand excavated from the mitigation site would be used in the dikes. The PZ27 wall fronting Gloucester Fish and the EDIC pier would be constructed with steel upon completion of cofferdams.

Construction Phase 2 Procedures - The floodgate concrete structures would be constructed on a dry river bed. The braced cofferdam is recommended as it would have less impact on flows in the river by taking up less room and cost less than a cellular type. Warranting consideration in design, in lieu of cofferdams includes floating the gate sections into place. Criteria for construction of the floodgates requires that safe navigation past the work area be maintained, as well as, the natural flushing and tide levels in the estuary. Currently planned, the floodgate structure would be constructed in three phases with a cofferdam constructed around gate sections separately. Figures 11, 12, and 13 show the phases of a "braced" cofferdam construction for Alignment #2. The water would be pumped out of the cofferdams and the gates would be built in the dry. The preliminary sequence of Alignment #2 construction phasing is to maintain a minimum of 5200 SF of flow area for safe navigation and estuary flows is: first, the navigation gate, and flushing gates #1-4 and wall on the Lynn side; second, the Revere gate, Lynn gates #5-9; and third, the Revere dike and walls. A navigation channel around the navigation gate cofferdam is required prior to installing the cofferdam. Also, required for floodgate alignments 3, 4, and 5 are the relocation or modifications of piers and General Electric's Pump House and pipeline. The cofferdams and navigation gate and flushing gates structure would be built with materials and equipment brought to the cofferdams by barges loaded in Lynn. Some materials and concrete placement can be accomplished from land at the Lynn end. After removal of the Revere wall cofferdam, the dike would be built from the Revere shore.

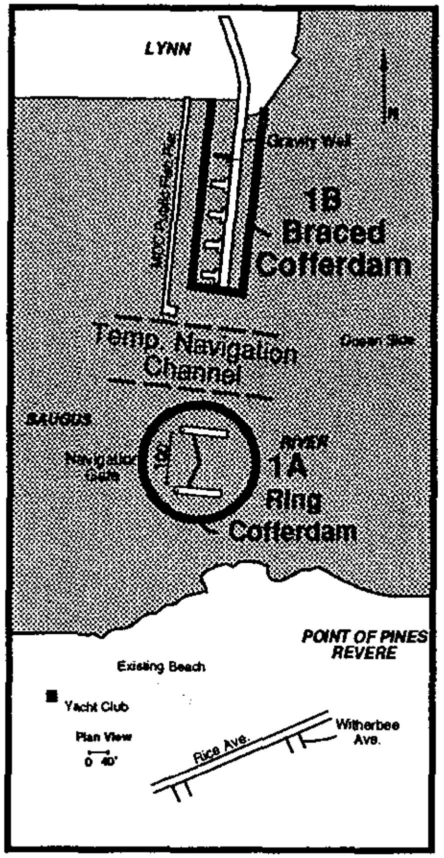


FIGURE 11

PHASE 1
CONSTRUCTION

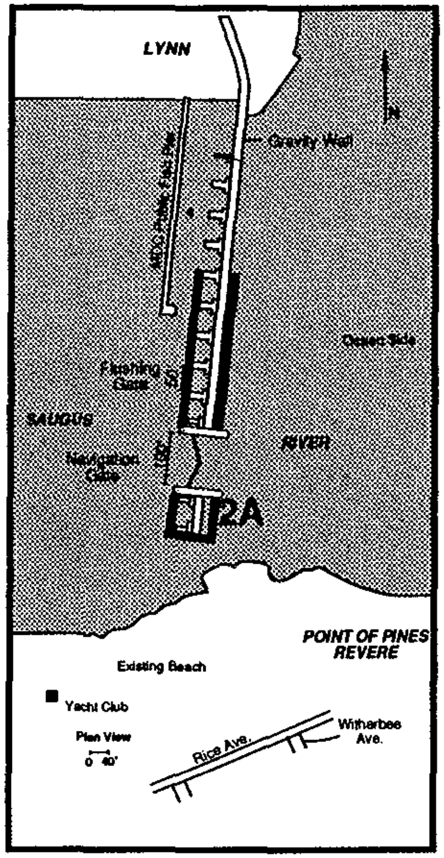


FIGURE 12

PHASE 2
CONSTRUCTION

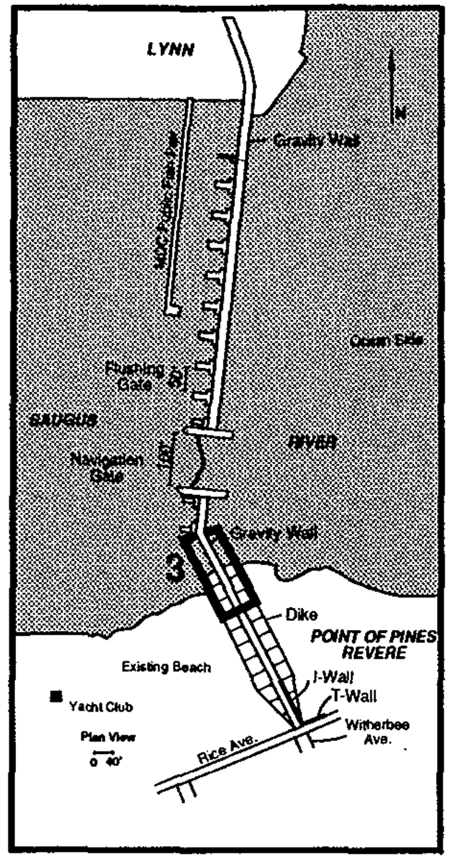


FIGURE 13

PHASE 3
CONSTRUCTION

Figures 11,12 and 13

Construction Phasing - The floodgates and other features would be constructed in various phases as design work is completed and to avoid impacts on the estuary or navigation during construction.

The Park Dike, Ponding Area gravity wall and Point of Pines' revetments, dunes, beach and wall and the mitigation site would start construction about 3.5 years after the start of design and be completed in about 12 months. Work along the Lynn shorefront would proceed concurrently with the Revere work with construction of revetments, and PZ 40, "I" and gravity walls over about the 12 month period.

The floodgates would follow completion of the other features. Modelling and design of the floodgates require about five years from the start of design. Construction would then follow over about 3.5 years, as follows for alignment #2(see Figures 11 to 13):

Floodgates

Phase	Description
1A	Dredge temporary navigation channel and river channel to finish grade and for cofferdams. Install ring cofferdam, then bearing piles (BPs) and build navigation gate over about 17 months.
1B	Concurrently, install braced cofferdam (BCD) then BPs for first 4 tainter gates and gravity wall on Lynn side and construct then remove BCD over about 18 months.
1	The flow area at mid tide is about 5,500 SF until BCD's are removed. Construction requires about 18 months plus about 3 months for dredging.
2A	With navigation gate open, dredge for remaining BCD's and install BCD for Revere gate and construct, about 6 months.
3A	After completion of the Revere tainter gate (2A) open it and proceed with the BCD then BPs and construct the Revere gravity wall followed by the Revere dike to EL.10, I-Wall and PZ27 wall in Lynn Harbor, about a six month period. During this period which overlaps phase 2B at least 5,300 SF of flow area is available.
3B	A 6 to 9 month consolidation of the phase 3A Revere Dike foundation is required. After the consolidation period, complete the Revere dike above EL.10. During most of this phase all gates are open and operable with the total 8,800 SF of flow area available at peak flow or mid tide. The total construction and consolidation time is about 3 1/2 years.

Construction Costs - The location where the floodgates would be constructed, either Alignments 1, 2, 3, 4 or 5, makes a significant difference in the construction and real estate costs for each alignment of the Regional Plan. See Table 23. Several factors make a significant difference in estimating the initial costs for alignments 1,3,4 and 5 since detailed layouts and cost estimates were not prepared:

(1) The impact on commercial real estate is expected to be higher for the developed areas west of the General Edwards Bridge. Permanent access to the floodgates and walls along the shore requires permanent easements which would limit the use of the land by commercial property owners.

(2) Construction of the navigation gate would require about a 210 foot diameter cofferdam, depending on the final size of the gate and detailed analysis of soil conditions. In either case, the cofferdam would prevent the passage of vessels under the General Edwards Bridge for <u>Alignments 3 or 4</u> east or west of the bridge for about 1 and a half years. This requires vessels to temporarily pass under adjacent spans of the bridge with limited clearance. About 20-30 sail boats are too high for this clearance and a temporary marina would be required east of the bridge. Also the General Electric fuel barges would be prevented from proceeding up the river and their fuel would need to be hauled by trucks (Aligns. 3, 4, 5). Delays in navigating the temporary channel would be experienced by the remaining vessels (Aligns 3, 4, 5).

(3) The length of the floodgate structure for alignments 1,3,4, and 5 require additional gravity walls to connect the structure to the north shore, and along the south shore to the bridge abutment. The costs are based on the unit cost of gravity walls developed for Alignment No.2. For alignments 3 and 4 the cost may be even higher due to the short sections of gravity walls with higher cofferdam costs located between flushing gates. The gates must be lined up between bridge piers.

The temporary marina would also be used by vessels whose docking area is rendered temporarily inaccessible by the cofferdams at alignments 3, 4 and 5.

In order to maintain a temporary navigation channel during the construction period, marina's docks and the General Electric saltwater in-take pipeline may need to be temporarily relocated for alignments 4 and 5 and then replaced if necessary. The underground cables for the bridge (Aligns 3 & 4) and communication cables under the river west of the bridge would likely need to be relocated (Aligns. 4 & 5).

For alignments 3 and 4, the pier footings for the General Edwards bridge would need to be protected from scour with a layer of stone along the river bottom.

The Lynnway drainage pipes in Lynn would be relocated to drains behind the gates. Also required for Alignments 3, 4, and 5 is a dike along Reach A of the Lynn Harbor bulkhead east of the bridge along the Saugus River.

Costs for relocations, bridge pier protection, temporary marina, real estate, and Lynnway drain relocations are included in the preliminary estimates for alignments 3, 4 and 5. Alignment 1 and 2 do not have these problems. An additional 5 % contingency is added to Alignments 3, 4 and 5 to account for relocation of underground cables, additional navigation aids under the bridge, cost of General Electric Hauling fuel, relocation of Revere drains, extending bridge pier footings (currently about EL.-13) below the dredge limit, additional costs of the gravity wall construction and delays encountered near the bridge and with vessel traffic and congestion.

TABLE 23

REGIONAL SPN PLAN COST COMPARISON
FOR FLOODGATE ALIGNMENTS # 1-5

Construction Costs (In $1000, 10/88 P.L.)	Floodgate Alignment 1	2*	3	4	5
(1) Floodgates:					
Navigation Gate	14,092	14,092	14,092	14,092	14,092
Tainter Gates 1-10	29,879	29,879	29,879	29,879	29,879
Gravity Wall to & along shore	6,900	1,883	7,500	6,800	10,600
Dike & I-Wall to shore	920	939	-	-	-
Lynn Harbor Reach A & Dike & drains	-	-	400	700	1,600
Relocations & Modifications:					
Fish Pier (if req'd) & Site Restore	920	986	920	920	920
Yacht Club & Gen. Elec. Piers Cables, Drains, Protect Y.C. Piers, Extend Bridge Pier footings, GE Truck Fuel Congestion Delays.	-	-	ND	ND	ND**
Temporary Marina	-	-	1,500	1,500	1,500
Stone Protec. Bridge Piers	-	-	600	600	-
Subtotal	52,711	47,779	54,891	54,491	58,591
Added Contingency (5%)	-	-	2,745	2,725	2,930
Floodgate Total	52,711	47,779	57,636	57,216	61,521
(2) Revere Park Dike, Gate & Wall	3,578	3,578	3,578	3,578	3,578
(3) Lynn Harbor, Reaches B-F	7,155	7,155	7,155	7,155	7,155
(4) Point of Pines (100 Yr.)	5,165	5,165	-	-	-
(5) Mitigation	391	391	391	391	391
(6) EDSA (21%)	11,230	11,230	11,230	11,230	11,230
(7) Real Estate	3,644	3,644	3,556	3,842	3,906
Total First Cost	83,874	78,942	83,546	83,412	87,781

* The Main Report includes the final cost of alignment 2 which may vary slightly from this comparison.

** Not Determined.

Operation and Maintenance of Regional Plan - Residents and environmental interests are extremely concerned that the operation and maintenance of the floodgates be accomplished so flooding is properly controlled and there would be no significant impact on the estuary. The Corps would prepare an O&M Manual for the project on how it is to be operated and maintained. O&M of the parkland and dike in Reach B would be an MDC responsibility. Responsibility for the other features, for example the ponding area wall behind Revere Beach and the Lynn Harbor walls and dikes would likely be the responsibility of those communities or the MDC.

Project features constructed as part of the Regional Project are described as four major features with estimated annual operation and maintenance costs as shown:

	O&M cost/year
(1) Revere Park Dike and Ponding Area	$ 14,000
(2) Point of Pines shorefront	11,000
(3) Lynn Shorefront	13,000
(4) Floodgates, Mitigation Site, Estuary Storage Protection	287,000
Total	$ 325,000

- Revere Park Dike and Ponding Area - Maintenance includes mowing and maintaining the parkland shrubs and trees and cleaning exposed retaining wall surfaces. The ponding area will require cleaning up of debris and assuring existing drainage pipes are not plugged from debris in the ponding area. This item also includes the inspection and maintenance of the Sales Creek tide gate to assure its continued operation.

- Point of Pines Shorefront - The maintenance and inspection includes the cleaning of debris off the revetments and walls, restoring sand for any eroded beach areas affecting the stability of the dunes, maintenance of dunes and crossovers and other access walks and gate.
Maintenance of grass, shrubs, and trees replaced along the shorefront is also included.

- Lynn Shorefront - Maintenance includes cleaning debris off of dikes and walls and assuring the operation of all gates. Maintenance of the stone facing on dikes and cathodic protection for steel sheet pile walls and eventual replacement of tide gates are included.

- Floodgates - The operation of the floodgates includes the assignment of two full time operators responsible for the operation and maintenance of the floodgates and monitoring of any activities in the area which may affect the storage area and mitigation site. They will also maintain and assure continued operation of monitoring and security equipment, and maintain landscaping and grounds. They would schedule and assure periodic maintenance of gates and operating equipment which costs are included. They would participate in the estuary storage protection measures outlined in the main report and semi-annual inspections by the Corps of the floodgates and storage area and mitigation site. Costs include the estimated maintenance, repair and replacement costs.

They would coordinate all closings of floodgates with the U.S. Coast Guard, Harbor Masters and public providing required advanced notice.

The total Operation and Maintenance cost is a non-Federal responsibility and must be financed by the non-Federal sponsor. O&M responsibilities will be clearly defined in an O&M manual prepared by the Corps during design. Compliance with the O&M manual is an item of local cooperation.

Maintenance of Existing Flood Reduction Features - The project requires the maintenance of existing non-Federally constructed project dependant flood reduction and shorefront structures. This is necessary to assure no significant increase in shorefront overtopping with an associated increase in damage. To facilitate monitoring of the existing project dependent flood reduction and shorefront structures a descriptive profile would be prepared in design extending from high ground at the Revere Beach Parkway at Sales Creek along the Revere and Lynn harbor shorefronts to high ground at Heritage Park.

Existing shorefront and flood reduction features include, for example,:

- the shoulder along Revere Beach Parkway fronting Cerratani's Market which protects the Garfield School area;
- the existing Revere Beach seawall and beach profile;
- any future developments along Lynn Harbor accepted for flood protection.

Benefits and Economics -

- Benefits - Benefits as explained in the Main Report for the Regional Plan varies depending on the location of the floodgates. Table 24 shows benefits for all alignments which include flood damage reduction, storm damage reduction, reduction in future costs, recreation and other cost saving benefits. The only difference is that alignments #1 and #2 which include Point of Pines protection also includes Point of Pines' benefits.

TABLE 24

ESTIMATED ANNUAL BENEFITS
REGIONAL FLOODGATE PLAN - Alignments 1-5

Project Benefits - SPN	Average Annual Benefits 1988 Price Level (1000) Align.1&2	Align.3-5
Flood Damage Reduction:		
Inundation Reduction	$ 6,968	$ 5,524
Sea Level Rise	1,132	947
Storm Damage Reduction to Shorefront Structures:	1,660	1,557
Reduction in Future Costs to MDC's Town Line Brook Project	78	78
Other Cost Savings:		
Emergency Costs	163	42
Future Development	141	141
Affluence	244	95
Flood Insurance Overhead	59	51
Recreation Benefits	415	415
Total	$ 10,860	$ 8,850

. Costs - The first Cost of the Regional Plan varies for two reasons:

(1) Construction costs for alignments 1 and 2 include Point of Pines features which are not included for Alignments 3, 4 and 5. Alignments 3, 4 and 5 include the additional construction costs previously discussed.

. Economic Analysis - The economic feasibility of the Regional Plan is also influenced by the different benefits and costs of each alignment, as shown on Table 25.

TABLE 25

REGIONAL SPN PLANS
ECONOMIC ANALYSES - Alignments #1 - 5

	Floodgate Alignment 1	2	3	4	5
Project First Cost ($ millions)	$ 84	$ 79	$ 83	$ 83	$ 87
Average Annual Benefits ($ millions)	10.8	10.8	8.8	8.8	8.8
Average Annual Costs ($ millions)	9.5	8.9	9.4	9.4	9.9
Average Annual Net Benefits ($ millions)	1.3	1.9	-.6	-.6	-1.1
Benefit-to-Cost Ratio	1.1	1.2	0.9	0.9	0.8

Environmental Impacts - The Regional Saugus River Floodgate Plan would directly cause the loss of the following acreage at Alignment #2. There would be only slight variations for other alignments. Impacts to be mitigated are summarized here, the EIS/EIR describes all impacts in greater detail.

Type of Land Impacted	Align #2
Intertidal - Lost	9.4
Subtidal - Net Lost	0.6
Total Acreage	10.0

The major environmental impact is the loss of about 10 acres of intertidal or subtidal habitat from the construction of the entire project which requires mitigation. The impacts from other alignments would be similar, except Black Duck feeding would be least impacted by Alignments 1, 2 and 5.

Impacts from Floodgate Alignments - Five floodgate alignments, numbers 1 to 5, were evaluated for costs and impacts at the mouth of the Saugus River as previously shown in Plate 14. Only alignments one and two require features described for Point of Pines.

- Alignment 1 - located 500 feet east of the existing MDC public fishing pier, requires a floodgate structure 1,600 feet long. The major concern is that it may adversely impact the dunes at Point of Pines depending on the influence the gates have on currents and waves during storm conditions. As with alignment 2, residents of Point of Pines fear their private beach may become a public beach, if the state finances their shorefront features resulting in degradation of the dunes' natural environmental and social resources. This concern will be coordinated with the state during the draft report review.

- Alignment 2 - located 700 feet east of the General Edwards Bridge, requires only a 1,275 foot long structure. Both Alignments 1 and 2 have slight impacts on Point of Pines during construction, since the floodgates would be constructed primarily from barges loaded in Lynn or from the Lynn side. Long term impacts on views to bordering neighbors and aesthetic impacts to the neighborhood would be reduced with landscaping, as well as protection afforded by the plans with these alignments. There is no significant interference with navigation during the phasing of gate construction, since a temporary navigation channel would be provided around the navigation gate work area.

- Alignment 3 - located 150 feet east of the General Edwards Bridge requires a structure 1,400 feet long and an additional 450 feet of revetment at its north end, along the Lynn Harbor bulkhead. It ties into the south embankment of the bridge. No protection is afforded Point of Pines which incurs a slight construction impact. Point of Pines may be adversely affected by this alignment with about a one foot increase in flood levels next to the gate structure near the yacht club opening to the neighborhood. Significant impacts of this alignment which increased the cost are:

- construction of 450 feet of dike along the Lynn bulkhead bordering the Saugus River;
- rock protection under the bridge to prevent additional scour;
- a temporary marina for vessels which cannot pass under adjacent spans of the bridge during closure of the navigation channel during gate construction;
- relocation of underground cables servicing the bridge, and drainage pipes in Revere;
- relocation of the Point of Pines Yacht Club piers;
- the cost of General Electric to have their jet fuel hauled by truck, since their tankers cannot pass under adjacent spans of the bridge during gate construction; and
- the additional navigation costs for temporary and permanent channels and protection of the bridge piers.

- Alignment 4 - located 150 feet west of the bridge requires a 1,350 foot long structure and 700 feet of additional revetment along the Lynn Bulkhead. In addition to similar costs incurred at Alignment #3, it also has much greater impacts on developed properties at each end of the Floodgate with higher real estate costs and relocation costs of piers and Lynn drainage outfalls. More interference would occur to the navigation fleet due to a restricted temporary channel during construction. Additional utility cables span the river bottom at this location.

- Alignment 5 - located 500 feet west of the bridge, requires a 1,620 foot structure and 1,550 feet of additional walls and dikes along both river banks to reach the bridge and Lynn Harbor. These additional structural costs, higher real estate impacts and costs on existing commercial property and future condominium and marina developments, relocation of a Lynn drainage system, and interference with navigation traffic and features results in the highest cost of any plan.

- Selected Alignment - Alignment #2 which shows the highest average annual net benefits is currently the selected alignment for Option 3. The alignment is also supported by the city of Revere. The Lynn and Saugus Citizen Steering Committees also prefer alignment #2. It provides protection to Point of Pines and has the greatest impacts, short term construction and long term views on Point of Pines residential area. The majority of the Point of Pines neighborhood and mayor of Revere support the alignment. Others in Point of Pines would support alignment #2 if the beach is allowed to remain in the ownership of the Point of Pines Beach and Conservation Association.

Concerns for the Estuary - Major concerns are whether the gated structure would affect the dynamics, water quality and sedimentation in the marsh and rivers and thus adversely impact on the extensive marine fisheries and wildlife in the salt water estuary behind the tide gates.

Analyses has shown that only minor impacts should occur for the following reasons.

- During normal times when the gates are open, there should be negligible changes in water quality as the openings would be designed to maintain the natural flushing and tide levels in the marsh and rivers.

- During storm tide conditions which normally occurs about two to three times a year, the gates would close causing temporary changes in water quality. These changes would not be significant because 1) only on infrequent occasions will there be a high amount of runoff coinciding with the high tide; 2) if there is a great deal of runoff, the length of time which the gates would be closed would be short, generally only than 1 to 2 hours; and 3) with future improvements in Lynn's Strawberry Brook combined sewer outfall into the Little River (Plate 19A), there may be no significant point source waste water discharges into the Pines and Saugus Rivers which could cause serious harm to the inner river system before the gates would be opened again. Under typical closures all of the wetlands would be submerged in saltwater for about the normal length of time.

Tidal and river currents and sedimentation will be changed immediately next to the gated structure, but should be similar to existing conditions within a few hundred feet of the structure.

Only a minor increase is expected in sediment buildup upstream when runoff occurs coincident with gate closure.

With an accelerated rate of sea level rise approaching 2 feet, twice the historical rate, there would be very little impact on the estuary. However, with higher rates and higher frequency and duration of closure more impact would be expected. If the rise is going to approach 2 feet, the flood protection plan should be evaluated for additional protection and operation requirements.

REGIONAL PLAN OPTIMIZATION - NED PLAN

The Regional Plan at Alignment 2 which produces the highest average annual net economic benefits of any option thus far needs to be optimized to determine the level of protection which produces the highest overall net economic benefits. The results would establish it as the "NED Plan" or the plan that provides the greatest contribution to National Economic Development.

Optimization of net benefits is accomplished by first determining if a feature or area is separate or independent of other features or areas. The following section discusses each of the following features or areas: the Crescent Beach area, Park Dike, Ponding Area, Point of Pines, Floodgates and Lynn Harbor. Only those features or areas determined to be separable are optimized, and then optimum features are combined to produce the NED Plan. Also, if elimination of any item does not affect damages in other areas, its determined separable, and must be separately optimized.

<u>CRESCENT BEACH AREA</u> - The Crescent Beach or Garfield School Area located behind the south end of Revere Beach was determined to be separate from the rest of the area. High ground at Beach Street separates this area from the rest of the study area's floodplain with the exception of the MBTA tracks which pass under Beach Street. A sand bag closure over the tracks is all that is needed to protect the area behind the Park Dike from flooding which may occur in the Garfield School area. Natural drainage of the Garfield area would not be affected by such a closure since this area drains south to Sales Creek.

Flooding of the Garfield area would occur from backing up of Sales Creek starting at about a 10 to 20 year tide event when Bennington Street is overtopped at the downstream end of Sales Creek, In 1978 floodwaters in the Suffolk Downs area was determined to be about EL.8 ft. NGVD, well below the Revere Beach Parkway by Cerratani's Market. Construction of the Roughans Point project would prevent 100 year (1978) flooding by way of the Eliot Circle intersection. Only a tide gate on Sales Creek is then needed for 100 year protection of Garfield. The tide gate was justified based on the damages prevented in the Garfield School Area.

A 500 year flood with a tide level one foot higher than 1978 would flood Roughans Point and Suffolk Downs to about Elevation 11 ft. NGVD and overtop both the Parkway, MBTA tracks under the Parkway and the Elliot Circle intersection. The cost of preventing the flow of water into the Garfield School area for a 500 year event with 2000 feet of walls, dikes and road raising significantly exceeded the additional economic benefits gained.

Therefore, the Garfield School area, as shown in the following analysis, can only be justified for protection to the 100 year level which produces the highest net benefits using a tidegate on Sales Creek. The gate would be closed if flood waters threatened to back water up the creek from Suffolk Downs.

Garfield School Area Economic Analysis

Level of Protection	First Cost	Annual Cost	Annual Benefits	Net Benefits
100 year	$ 29,000	$ 3,000	$106,000	$103,000
500 year	$1,015,000	$85,000	$136,000	$ 51,000

PARK DIKE - The park dike prevents tide waters overtopping the Revere seawall from entering developed areas behind it and along its drainage course (County Ditch) to Diamond Creek and the Pines River. The estimated volume of water overtopping the seawall for events ranging from 100 year to the SPN event are 695 to 2390 Acre-Feet of water. There is no way to separate this area from preventing flood waters from naturally flowing down the county ditch under Revere Street toward Oak Island. In the future this drainage course under Revere Street would most likely be opened to about 100 feet wide for extending the MBTA Blue Line tracks to Lynn. This water contributes to the flooding of the Wonderland area, Towle area, Revere High School area, Kelley's Meadow, Oak Island area and into the estuary affecting the storage in the estuary which is used to protect areas surrounding the marsh. The Floodgates also are needed to prevent flooding of this same area from the Pines River. Since this area is not separable, it does not warrant separate optimization.

PONDING AREA WALL - The area behind the north end of Revere Beach was analyzed separately since residents in the area reported very little damage resulting from water overtopping the concrete stepped seawall. The 100 year to SPN volumes of overtopping were estimated to range from 255 to 1165 acre-feet. The ponding area behind these homes is nearly large enough to hold the 100 year volume with any excess overflowing Rt. 1A (North Shore Road) and flowing back into the estuary with very little damage to homes in the area. The storage area in the estuary could handle this volume of water. The water must be directed toward the estuary and not allowed to flow south along Revere Beach Boulevard to lower developed areas. A 500 foot long wall at the south bank of the ponding area would prevent water from flooding south to Kelley's Meadow and Oak Island areas and beyond. The ponding area wall is not a separable feature since the Floodgates, and other features are used to reduce damages behind Revere Beach.

The control of the estuary reduces damages to this area. Protection of the area at the north end of the beach can be considered separable. Protection of the ponding area's wetland storage is the next level to reduce damages. Protection of the storage area can be accomplished with existing wetland regulation enforcement at no significant cost to the plan. The next level:

To raise the 1800 foot Revere Beach seawall only 2 feet and provide additional protection to the area behind the north end of the Revere Beach seawall is not justified. The cost to raise the wall is about $2 million. An annual cost of $180,000 exceeds the maximum benefits ($21,000) to be gained.

POINT OF PINES - The Point of Pines area, during most of the study, was assumed to be protected by the separate local protection project approved for construction to protect the area at the optimized 100 year level with a design tide of EL. 10.3 ft. NGVD. The Regional Plan was initially formulated assuming the project would be built prior to the Regional Plan. Consequently, for events exceeding the 100 year level, flood waters overtopping at the 500 year and SPN levels into Point of Pines would be stored in the estuary. When the city of Revere advised the Corps the project could not be built, late in the study, the project was checked to see if a higher level could be justified when integrated with the Regional Plan. The following summarizes the analysis which shows Point of Pines remains optimized at the 100 year level.

Point of Pines Area Economic Analysis

Level of Protection (1989 Tides)	First Cost ($millions)	Annual Cost ($1000)	Annual Benefits ($1000)	Net Benefits ($1000)
10 year	$6.4	$609	$1529	$ 920
100 year	$6.5	$618	$1947	$1329
500 year	$7.3	$690	$2011	$1321

If the Regional Plan proceeds into final design, the dune/beach model would be used to access the feasibility of using sand for a dune/beach system possibly in lieu of all or part of the revetments.

LYNN HARBOR - Shorefront protection along Lynn Harbor also can not be separated or eliminated from the rest of the plan. The existing walls and shorefront range from about EL. 8 to 11. The 100 year to SPN stillwater tide levels in Broad Sound range for EL. 10.3 to 12.0. The waves for these storms flows in freely flooding not only along the Saugus River at General Electric as the water flows to the estuary exceeding its storage capacity used to protect the other communities. The Floodgates are also required to protect the same area from overland flooding of the Pines River. Therefore, since protection along Lynn Harbor is not separable, it does not warrant separate optimization.

FLOODGATES - The floodgates can not be separated from the Park Dike, Ponding Area Wall, Point of Pines or Lynn Harbor features or eliminated from the rest of the Regional Plan for separate incremental justification. Without the floodgates, floodwaters would affect the entire study area. Separate optimization is therefore not required.

REGIONAL PLAN - Optimization of the Regional Plan is therefore accomplished by varying the height of all other structures to achieve various design stillwater tide levels of EL. 10.3, 11.2 and 12.0 ft. NGVD, or (at 1989 tidal conditions) levels of protection (e.g., 100 year, 500 year, and SPN). The Park Dike, Ponding Area Wall, Floodgates and Lynn Harbor shorefront which are not separable are all evaluated together for each design stillwater level. The Sales Creek Tide Gate and Point of Pines which were justified separately are held constant during optimization of the other features.

SPN plus 1 foot Plan

The feasibility of increasing the design level of protection to account for one foot of future sea level rise over the next 100 years assumes the requirement to raise all structures in the SPN plan by one foot higher (Alternative 1), plus several additional features to prevent all the damages from one foot rise (Alternative 2). The design stillwater tide level (SWL) would be EL.13 ft. NGVD. The following reflects the changes required in the SPN Plan for an initial analysis of an SPN + 1 foot plan.

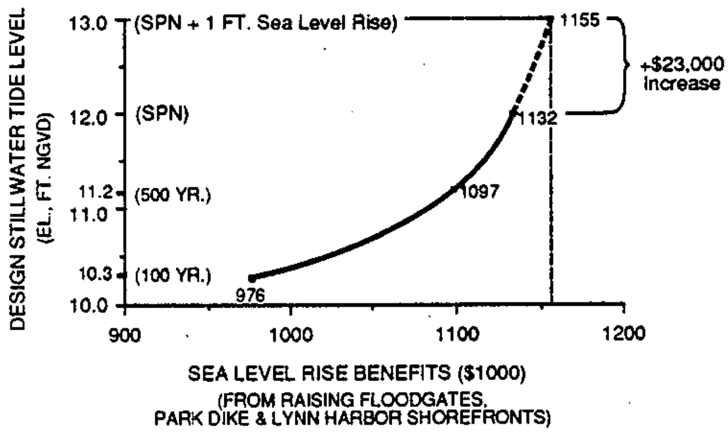
Alternative 1 - Raise SPN Plan Features - The incremental cost of raising the SPN Plan features used to optimize the Regional Plan by about one foot to reduce the affect of one foot rise in sea level, is explained in the next paragraph and summarized as follows:

		Estimated Increased Costs ($ Millions)
Floodgate, Park Dike, "M" Ponding Area Wall, Lynn Harbor Reaches B-E	-	$1.3
Lynn Harbor Reach F Wall	-	0.1
	TOTAL:	$1.4 Million increase

Total Alter. #1 First Cost: SPN Plan @ $78.9 m + $1.4 mill. Increase = $80.3M
Alternative #1 Average Annual Cost: $9070k

The incremental sea level rise benefit was estimated from graphing the sea level rise benefits for the three plans (100 year, 500 year and SPN) which were used to optimize the Regional Plan with design stillwater tide levels of Elevation 10.3, 11.2 and 12.0 ft., NGVD. Projecting the results to Elevation 13.0 provides benefits for one foot higher than the SPN plan or an increase in benefits of $23,000.

Alternative #1 Benefits(in $1000): SPN Plan @ $10,860k+23=$10,883 K
Alternative #1 Net Benefits = $10,883k - 9070k =$1813 K



Alternative #1 produces higher net benefits that Alternative #2, which follows, and is therefore shown in Table 26.

Alternative #2 - Raise all Overtopped Shorefront Features -

Alternative #2 includes raising by about one foot all shorefront features subject to overtopping by an EL.13 tidal storm.

SPN plus 1 foot Plan

The existing Regional Plan features which increased from a design SWL of EL.11.2 to 12 had a construction cost increase of about $1.4 million. Part of this increase was due to the addition of an 1100 foot gravity wall in Lynn Harbor Reach F which cost about $450 K. Except for the wall, the project increased 0.8 feet in height for a cost increase of $1 million.

Therefore, a 1.0 foot increase in the height of the floodgates, park dike, Reach "M" wall and Lynn Harbor (LH) Reaches B to E is about $1.3 million.

The additional cost of raising the Lynn Harbor Reach F wall is about 20% (1 foot in five feet) or about $0.1 million.

To prevent the additional foot of damages, both Point of Pines and the North end of Revere Beach would be raised about a foot. Costs for raising the north end of the Revere Beach seawall was developed at $2.3 million for 1800 feet (Reaches C58 and D1). In addition another 900 feet in Reach D2 would be raised at a similar cost per linear foot or about $1.2 million.

The cost of raising Point of Pines revetments, walls and dunes one foot is estimated at an additional cost of $1.6 million.

The total increase in the project cost is summarized as follows:

	Estimated Increased Cost ($ Millions)
Floodgate, Park Dike, "M"-Wall, L. Harbor B-E	$ 1.3
Lynn Harbor Reach F Wall	0.1
Raise Revere Beach Wall (C5B & D1)	2.3
Raise Revere Beach Wall (D2)	1.2
Raise Point of Pines features	1.6
	$ 6.5 Million Increase

The total First Cost is the cost for SPN protection ($78.9M) plus 1 foot (+$6.5m), or a total of $85.4M. The maximum additional benefits due to sea level rise is the residual annual damages not prevented by the SPN plan, or $ 328,000 (say $330 K) in maximum potential benefits. In addition to sea level rise benefits, additional benefits result to the North end of Revere Beach at a maximum value of $18,000, and to Point of Pines which is the additional benefits between 100 year and 500 year protection (excluding sea level rise benefits) or $38,000. The total benefits (in $1000) therefore, include: the SPN plan at $10,860; $330; $18 and $38, for a total of $11,246.

Alternative #2 Economic Analysis follows:

Total Benefits	$11,246,000
Aver. Ann. Cost	$ 9,650,000
Alt.#2 - Net Benefits	$ 1,596,000

Raising the project for design SWL level of EL.13 ft. NGVD would not be justified based on this initial analysis.

Regional Plan Optimization

Table 26 summarizes the first cost and economics for four levels of protection by the Regional Plan for design stillwater tide levels (DSWL) of Elevations 10.3, 11.2, 12.0 and 13.0 ft. NGVD, or at 1989 tide conditions: 100 year, 500 year, SPN and SPN plus 1 foot (Alternative #1) for sea level rise.

Table 26
Regional Plan Optimization

Level of Protection	First Cost ($millions)	Annual Cost ($1000)	Annual Benefits ($1000)	Net Benefits ($1000)
Alignment #2:				
100 year	$76	$8,671	$ 9,829	$1,158
500 year	$77	$8,756	$10,573	$1,817
SPN	$79	$8,942	$10,860	$1,918
SPN+1 ft.	$80	$9,070	$10,883	$1,813
Alignment #1:				
100 year	$81	$9,199	$ 9,829	$ 630
500 year	$82	$9,294	$10,573	$1,279
SPN	$84	$9,489	$10,860	$1,371
Alignment #3:				
100 year	$81	$9,143	$7,892	-$1,251
500 year	$82	$9,237	$8,562	-$ 675
SPN	$84	$9,430	$8,850	-$ 580
Alignment #4:				
100 year	$81	$9,129	$7,892	-$1,237
500 year	$82	$9,222	$8,562	-$ 660
SPN	$83	$9,415	$8,850	-$ 565
Alignment #5:				
100 year	$85	$9,607	$7,892	-$1,715
500 year	$86	$9,707	$8,562	-$1,145
SPN	$88	$9,911	$8,850	-$1,061

The analysis shows that the Floodgates at Alignment #2, Lynn Harbor and Park Dike achieve their maximum net benefits at the SPN level while Point of Pines produces its highest benefits at the 100 year or minimum level needed to stabilize the Regional Plan SPN protection.

Accelerated Sea Level Rise - Generally, two basic alternatives could be investigated if accelerated rise approaches or exceeds two feet.

First Option: The existing shorefront structures could be raised to reduce overtopping and the floodgates continue to operate more frequently and for a few hours longer each time.

If sea level rise approaches four feet, navigation locks and pumping stations may need to be installed to allow vessels unrestricted access through the floodgates, and provide for interior drainage. Closure of floodgates would be occurring so frequently under the four foot of rise which means the former Standard Project Northeaster levels of EL.12 ft. NGVD would be occurring once a year. Permanent closure of the estuary from tides would be one option, however, an unpopular option due to the potential environmental impacts.

Second Option: With accelerated rates approaching or exceeding two feet besides raising structures along the coastal shorefront, low level walls and dikes of 2, 3 or 4 feet, depending on the rate of rise, could be constructed around the estuary. This would effectively raise the start of damage so to keep the estuary open to natural flushing as proposed under current conditions and provide the needed storage area. This alternative would likely be more cost effective and acceptable than the first option.

If the rise approaches four feet, low level walls and dikes, would likely be less costly than locks and pumping stations. However, many conditions would need to be considered in an investigation to determine the value of an estuary which may be losing its vegetated wetlands to mud flats, and an increasing problem of interior drainage. Under this worse case of four foot rise, according to the National Research Council, four feet would not likely be reached for another 100 years at the earliest. A two feet rise would not likely occur until 70 years, at the earliest. Once the actual rate of rise is determined in about ten to twenty years, there would be ample time to consider and implement adjustments in the plan.

POINT OF PINES WORKSHOP AND SURVEY

General - A brochure was mailed to 429 residents in Point of Pines, prior to the 30 June 88 Workshop held at St. John Vianney Church at Point of Pines. About 80 people attended the 7:00 to 9:30 pm meeting on a rainy evening. A 30 minute slide presentation was provided on the problems, options and Regional Plan. Fifty-four (54) residents returned the survey postcard. Altogether about 115 people (25% of residents) either attended the workshop and/or responded by the postcards.

The post card survey of Point of Pines' Residents revealed the following:

"Do you support the Regional Plan including Flood Protection for Point of Pines?"

Yes (some with certain conditions met): 35 (65%)
Don't Know: 6 (11%)
No, unless certain conditions met: 4 (7%)
No support: 9 (17%)

TOTAL 54 (100%)

Comments received in the Post Card Survey were:

Yes - Respondents

- It is something that's been needed a long time and will stop the flooding in this area.
- We live in fear of another storm.
- Since 1946, the flooding has gotten much worse. We lived through ones in 1972, 1978 and 1979. Anything that would alleviate this situation would be most welcome.
- I have lived here 5 years and I have noticed visual erosion on Rice Ave and the wall area.

(Continued)

Yes - Respondents (Continued)

- Any plan is an improvement for flood control.
- With others, I am concerned about the environmental protection of the area.
- Plan is unacceptable without protection afforded by wall, revetment, dunes and beach in Point of Pines.
- "Corps" to maintain gates and flood control areas.
- Prefer O & M & R responsibilities of Point of Pines Beach by MDC rather than city if beyond financial capability of Beach Associations.
- Beach must be kept private and improved after workshop is completed.
- Flood protection for the Pines must be uppermost.
- Make the Pines Beach a Public Beach with resident parking only on all streets. Have MDC maintain beach and enforce parking violations.
- I would like the most feasible and most economical project.
- This is contingent on the Point of Pines' project to be done also.
- If Point of Pines' beach will continue to be private, a must. If the floodgates are going to help all of Rice Ave. from not flooding. Who will maintain upkeep and repairs to floodgate in the years to come - costs?

Don't Know Responses:

- Keep the MDC and local politicians out of the master planning..
- I am in full support of Plan for beach.
- What becomes of the privacy of our beach? Construction problems?

No Response, unless following conditions are met:

- Why aren't we increasing the height of seawalls for flood protection?
- Feel the possibility of losing beach areas. Residents want this beach area to stay.
- We want protection for all of Rice Ave. The wall should be higher and longer.
- This project does not reflect any assistance to the Point of Pines' flooding and care of the beach front.

No Support Response:

- Steering Committee has no representatives from beach association.
- Too costly and benefits do not outweigh the disturbance to community, risk of loosing private beach and spoiling the beauty of the area. - ugly gates and waste of Federal money.
- I support most aspects of this plan but I am totally opposed to the flood-gates.
- I don't like the floodgate proposal.
- Nothing will make it acceptable, leave my beach alone.

Summary of Workshop Comments:

a. Flood protection is needed.

b. A strong fear that their private beach and dunes would be lost if opened to the public use, as a result of this project.

c. If the beach could be kept private, a number of people were agreeable to raising walls 2 to 3 feet higher.

d. Several people voiced an imbalance of benefits versus impacts. They pointed out that Point of Pines bears much of the visual and construction impacts while the whole region benefits.

e. There was a strong concern that the Corps should operate and maintain the floodgates to assure its effective and proper operation.

f. After the meeting, Councillor Rosa requested Mr. Stringi prepare a letter of support for the plan with appropriate conditions listed for sending to legislators.

g. Other questions addressed such issues as:
- Where will the flood waters go, if it doesn't enter the estuary - cause flooding elsewhere?
- Why are people being allowed to fill wetlands? This leaves no place for water to drain to.
- How long will construction take and can they be constrained to work only regular working hours?
- Could the floodgates be moved closer to the bridge to eliminate impact on views and beach loss?
- Will it be possible for the community to have a representative working with the Corps in the future to monitor progress?
- What kind of security would there be?
- Can the association maintain the beach rather than MDC or city?
- Any improvements to pump station?
- Is the plan a forgone conclusion or can it be stopped?
- Aren't breakwaters cheaper and less impacting?

ADDENDUM 1

PUBLIC VIEWS DURING PRELIMINARY PLANNING

ADDENDUM 1

PUBLIC VIEWS AND RESPONSES

The following are public comments received in letters prior to public review of the report.

U. S. CONGRESSMEN

Nicholas Mavroules - "...the use of floodgates on the Saugus River, could offer a complete solution to eliminate the threat of flooding, and yet maintain both river navigation and preservation and enhancement of the Saugus Marsh." (Feb. 25, 1986)

"...I reiterate my support for the proposed flood damage reduction plan for the Saugus River and Tributary on behalf of the communities of Lynn, Saugus, Revere and Malden, Massachusetts. I must concur that the preliminary plan that incorporates the use of floodgates on the Saugus River tied into shorefront protection along Revere Beach, Lynn Harbor and Lynn Beach would offer the maximum protection to the 5,000 residential, public, commercial and industrial buildings and several major arteries in this area." (Apr. 13, 1987)

Edward J. Markey - "...Let me reiterate my concern for the safety of the Revere shoreline and my commitment to assist the Corps and the City of Revere with its long term protection." (Mar. 4, 1982)

"...I am writing to express my strong support of the project undertaken by the U.S. Army Corps of Engineers in developing a flood damage reduction study for the Saugus River and its tributaries. This project is of great importance to the cities of Revere, Malden, Lynn and Saugus. Given the history of severe flooding and extensive property damage to local businesses and residences in these communities, I urge you to complete this study and continue development of a comprehensive flood control plan. This is a project that I fully support and one that will benefit the citizens of Revere, Malden, Saugus and Lynn." (Apr. 8, 1986)

STATE LEGISLATURE

Representative Alfred E. Saggese, Jr. - "...I am writing to voice my strong support for the Flood Damage Reduction Study undertaken by your office in the communities of Revere, Lynn, Saugus and Malden. As you proceed into the final selection phase, please be assured that I am prepared to assist you at the legislative level. I will work to insure that you receive ample funding." (Apr. 29, 1986)

FEDERAL AGENCIES

Fish and Wildlife Service - "...The Broad Sound Area supports a wide variety of significant fish and wildlife resources. These include shellfish and other marine invertebrates; anadromous, catadromous, and marine fishes; resident and migratory birds, including waterfowl, shorebirds, wading birds, sea birds, passerines and raptors; and resident mammals. The Saugus-Pines River Estuary, with over 750 acres of salt marshes, mudflats, and shallow subtidal channels, is one of the most biologically significant estuaries in Massachusetts north of Boston." Gordon E. Beckett, Supervisor, New England Area. (Jun 22, 1988)

"...The importance of the Saugus and Pines River estuary cannot be overemphasized since it contains a wide variety of public trust resources. Nearly 70 percent of all commercial fish and shellfish resources are dependent upon estuaries for spawning and nursery grounds. One of the primary issues regarding your preferred alternative is how the tidal barrier would impact the estuary and the organisms dependent upon it. We are also concerned that a closed floodgate could alter the pH, salinity, temperature, dissolved oxygen and contaminant accumulation as freshwater runoff from interior storage areas become locked into the marsh during storm events."

"...The I-95 embankment acts as a barrier to incoming tides, reducing the historic high water mark by at least six inches. Restricted flows through the floodgate in combination with the I-95 embankment will further reduce the amount of water reaching the back of the marsh. It is our understanding that one of the arguments for not removing the I-95 embankment is that it acts as a barrier in reducing flood waters from adversely impacting the Towns of East Saugus and Saugus, except during unusual severe storms. Since the material in the embankment is earmarked for various state and federal projects, we encourage the Corps to work with those agencies to remove the I-95 embankment. Removal of this impediment will enhance the quality and characteristics of the estuary by allowing an additional minimum of six inches of tidal water to circulate through the back portions of the marsh."

"...The Service recommends the Corps identify the landowners of the estuary and explore the possibilities of purchasing the marsh to preserve its functions as floodwater storage, fisheries and wildlife habitat and recreational values. The estuary is an outstanding resource in an otherwise urban environment. As such, it is worthy of special management consideration."

" The Service is also concerned that implementation of the floodgate option may stimulate secondary development in and along the fringes of the marsh."

"...The four local protection plans being considered under Option 1 also have the potential to adversely impact the estuary." Vernon Lang, Acting Supervisor, New England Area. (Nov 9, 1987)

FEDERAL EMERGENCY MANAGEMENT AGENCY

"...We have examined both the Project Information Report and the Draft (EIS) Outline and agree that Option # 3 the Regional Saugus River Floodgate Plan would represent the most beneficial solution for tidal flooding protection in this area." Edward A. Thomas, Chief, Natural & Technological Hazards Division. (Jul 2, 1987)

NATIONAL MARINE FISHERIES SERVICE

"...The Saugus/Pines River Estuary supports populations of valuable fishery resources such as winter flounder, alewife, American eel and soft shell clam. The estuary provides spawning, nursery, and feeding habitat for these and other aquatic species, and is bordered by extensive salt marsh wetlands and intertidal mudflats. Any structural method of reducing flood damage must provide for the maintenance of these aquatic populations and habitats." Thomas E. Bigford, Branch Chief, (Jul 2, 1987)

"...Overall, we will be recommending the development of a project that is the least environmentally damaging to aquatic resources. Efforts to avoid or reduce the filling of tidal wetlands, maintain tidal flushing and circulation, and minimize the disturbance of fish and shellfish populations should be pursued." Bruce E. Higgins, Deputy Chief, (Dec 2, 1985)

U.S. Environmental Protection Agency.

"...We believe from a Section 404 and overall environmental perspective, Option #3 with a floodgate structure near the General Edwards Bridge is the most promising action. Minimal wetland loss and maximum flood protection appear to be achievable while maintaining existing hydrological conditions, vegetation, fisheries, wildlife, and current uses. Identifying the 100 year and 500 year floodplain elevations and requiring the purchase or easement acquisition of the floodway for flood retention could in the long term be an important measure in educating the public and local governments to the resource values in the Saugus and Pines River estuaries, and the need to protect the estuaries from development, unregulated fill, and dumping. We support the continued study of no action, Option #1 and Option #2 for comparative alternatives and environmental analyses under Section 404 and NEPA, but believe these alternatives could result in lower flood protection and higher environmental costs.

EPA's main concern with the proposed project is the protection of the existing saltmarsh estuary. As you know, the Pines River Watershed and the Saugus River Watershed, including adjacent wetlands and direct tributary systems, are included as a priority waterbody/wetland in "EPA's

Priority Wetland Listing for New England." This designation as a priority waterbody/wetland is due to the high resource values (extensive mudflats and saltmarsh; anadromous fish; large population of softshell clams, and other shellfish; and, winter flounder and smelt spawning grounds) threatened by further industrial development in an already stressed ecosystem, creation of federal navigation channels, and expansion of marine facilities."

The Massachusetts Coastal Zone Management Plan recommends, "that the Saugus/Pines River Marsh be the highest priority for restriction under the state's Wetlands Restriction Programs." Unfortunately, the Massachusetts Coastal Zone Management Plan and the Massachusetts Wetland Protection Act, even in combination with federal wetland and flood protection regulations, have not been highly effective in protecting the resources of the Saugus and Pines River estuaries. Elizabeth A. Higgins, Assistant Director for Environmental Review. (Jun 17, 1986)

STATE AGENCIES

Executive Office of Environmental Affairs

"...Recently, I sent you a copy of my November 9, 1987 letter to Commissioner Geary of the Metropolitan District Commission accepting with great pleasure the MDC's offer to serve as the Commonwealth's joint proponent with the communities of Lynn, Malden, Revere, and Saugus and the U. S. Army Corps of Engineers on the Saugus River Flood Damage Reduction Project. This marks a milestone in the continued intergovernmental cooperation on this project.

I want to reiterate my strong support for this process. I would also like to thank you for the active role of the Corps in fostering both the process and the spirit of cooperation. In this regard, I assure you that the Commonwealth will continue to work with the Corps in assessing the appropriate course of action for this project." James S. Hoyte, Secretary. (Dec 14, 1987)

"...Dear Commissioner Geary: It is with great pleasure that I accept your offer to serve as the Commonwealth's joint proponent with the U.S. Army Corps of Engineers in the Flood Damage Reduction Project. This project is of great importance at all levels of government and, as you point out, relates closely to several ongoing efforts by the Metropolitan District Commission. Thus, I do hereby confirm the MDC as a joint proponent on EOEA #6497 and shall publish a notice of this determination in the next issue of the Environmental Monitor.

"...Again, it is with pleasure that I accept your offer; it marks a milestone in cooperation for this project and will help to assure a successful conclusion." James S. Hoyte, Secretary. (Nov 9, 1987)

"...In general, the Commonwealth prefers nonstructural flood damage reduction solutions, such as floodproofing, which clearly pose lesser environmental impacts. As your proposal develops, more substantative data will become available that will allow for a comprehensive assessment of the proper remedial option." James S. Hoyte, Secretary. (Feb 19, 1986)

METROPOLITAN DISTRICT COMMISSION

Re: Proponent State Agency

"...Dear Secretary Hoyte, The Metropolitan District Commission has a vital interest in this project. Important areas of mutual interest exist between the Corps and MDC that synchronization is a necessity for flood control structures, modes of operation and the hydrology and hydraulics of the Saugus Marsh. On September 24, 1987, the U.S. Army Corps of Engineers presented a briefing of their project to the MDC, cognizant of our associated project for flood control at Town Line and Linden Brooks, including the Revere Pumping Station and the Revere Beach Master Plan. Colonel Rhen and I discussed the interfacing of our responsibilities and concluded that continued coordination will be beneficial to the public by reducing construction costs and sharing project benefits in three major areas of concern.

"...Chief among these is the Corps' intended...flood reduction, including a flood barier across the mouth of the Saugus River downstream of the General Edwards Bridge... The next area of concern is the MDC park dike at Revere Beach. This represents the solution to the wave overtopping at Revere Beach. The Corps has adopted the MDC Master Plan for a secondary seawall and park diking to form a storm water retention basin in this area. The third area of interest is the Corps' barrier project is on or adjacent to MDC property including parts of the Saugus and Pines Rivers, Lynn and Revere Beaches.

My wish is to culminate the flood protection project by restoring the natural beauty of the marsh and environment with a public park which would enhance the marsh, prevent further urbanization and encroachment. I recommend that you name the MDC as the proponent state agency because of these advantages." William Geary, Commissioner. (Oct 9, 1987)

"Option 2. Nonstructural Plans - MCZM favors this alternative because it provides reduction in flood damages yet does not encourage continued encroachment in floodprone or environmentally sensitive areas. A detailed economic analysis must be provided that documents why this option is not a feasible alternative.

"Option 3. Regional Saugus River Flood Gate Plan - A delineation and discussion of the wetland areas within the study areas, similar to the one requested for Option 1, would be necessary for this option. In addition, a complete analysis of the present flushing characteristics of the estuary must be completed. This analysis must address tidal circulation patterns, flushing rates, that amplitude and phase, sediment transport rates and disposal patterns. A complete ecological survey of the estuary must also be included in this analysis. Once the existing conditions one fully understood, the affect of the tidal gate on these same parameters must be analyzed. The final placement site of the tidal gate could also potentially affect storm surge level to areas immediately adjacent to the tidal gate. Therefore a detailed surge model should be generated for Broad Sound.

"General Comments. It would seem appropriate that the expenditure of such a large some of taxpayer money should produce some type of public benefit that can be utilized by everyone, especially since the private sector will benefit so much from this project. Public walkways or fishing areas should accompany all of the options.

"The selection of either Option 1 or Option 3 would directly increase the encroachment of development on the Saugus River estuary. Providing flood protection to the upland floodplain will encourage more residential and industrial development of the area. Whatever option is finally selected, it must incorporate the long-term protection of the Saugus Estuary. It will be required that some type of long-term proteciton is a component of the final plan.

"It is well documented that relative sea level rise has been ongoing at an approximate rate of one foot per century for at least the past several hundred years (based on tidal records). The Environmental Protection Agency has generated estimates that this rate could increase substantially in the next 100 years. Because this project is expected to have a life expectancy of 100 years, the planning of this project should incorporate an analysis of the future effectiveness of the project based on the present day rate of relative sea level rise. Consideration should also be given to the EPA estimates of future sea level rise rates.

"Please be advised that this project will be subject to federal consistency review by this Office before any federal action can be taken." Richard F. Delaney, Director, MCZM. (Apr 23, 1987)

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

"...Following review of the three options, it is the Department's opinion that Option #2 would result in least impact on the interest identified in the Wetlands Protection Act. Options #1 and #3 would probably result in significant alternation of a number of coastal resource areas; including Salt Marsh, Coastal Bank, Barrier Beach, Coastal Dune, Coastal Beach, Land under the ocean and possibly Land Containing Shellfish. The Department, in recognizing the local flooding problem, would favor Option #2 or any other option that would result in the least amount of destruction/alteration of the resource areas identified in the Wetlands Protection Act. The department would also favor any option that would restrict further development in areas proned to coastal flooding." William A. Krol, P.E., Deputy Regional Environmental Engineering. (Feb 12, 1986)

"...The Department is concerned with water quality of the rivers and estuaries to make sure they meet the water quality standards and classification assigned to the rivers."

"...The Department feels the main problem with options one and three in the proposal is the impact on the wetlands."

"...Any alteration of the natural course of flow for the rivers will change the currents and stream flow. This could cause settling of solids in backwaters, thus filling in the wetlands and stream channels or cause scouring and sediment resuspension where new currents and backwaters are created. Furthermore, a change in saltwater - freshwater mixtures could cause a change in biological habitats and communities. If death or decay of living organisms occurred, water quality degredation could occur." Margo T. Webber, Assistant Sanitary Engineering. (Feb 3, 1986)

ENVIRONMENTAL IMPACT REVIEW

"...Floodproofing appears to offer the least potential for environmental impact, but may not offer cost effective damage reduction. The local protection alternative appears to have the greatest potential for impacts to wetlands, unless the barrier structures can be moved landward to avoid fill in and disturbance to wetlands. The barrier alternative may offer the most complete flood protection, but also has the greatest potential to affect the dynamics of the estuary." Samuel G. Mygatt, Executive Director, EIR. (Dec 13, 1985)

DIVISION OF FISHERIES AND WILDLIFE

"...Remaining wetlands in Massachusetts are all valuable and any plans to protect structures built on flood plains should not be at the expense of salt marsh habitat.

...We would prefer seeing Option #2 but believe Option #3 would be preferable to Option #1 since it would minimize impact on salt marsh ecology with minimal habitat destruction." H.W. Heusmann, Waterfowl Biologist, (Dec 12, 1985)

DIVISION OF MARINE FISHERIES

"...As I stated at the November 19th meeting, our main concerns will be loss of marsh and/or shellfish habitat, effects on anadromous fish, and changes in the hydrology of the system which result in slower flushing of contaminants, changes in tidal amplitude, or changes in water quality, especially salinity." James J. Fair, Jr., Assistant Director. (Nov 20, 1985)

CITY OF LYNN

MAYOR OF LYNN

"... Please be advised that, as the chief elected official of the City of Lynn I would like to be recorded in favor of the Regional Saugus River Floodgate Plan, as the preferred alternative to protect our coastal area from further flood damages."

"...I have reviewed the facts presented with the Environmental Notification Form for the project and support this plan, within its high economic benefits, high degree of protection and reduced environmental impacts, for additional study to address the control of this regional coastal flooding problem." Albert V. DiVirgilio, Mayor. (Mar 23, 1987)

"...I reassert the City of Lynn's strong support for the project which will prevent tidal flooding. We also reiterate our offer of assistance in whatever capacity needed to expedite a solution." Albert V. DiVirgilio, Mayor. (Mar 11, 1986)

"...The city of Lynn requests that the Army Corps of Engineers investigate flooding conditions and determine the feasibility of constructing a flood control project. Tidal flooding has been a continuing problem both from Lynn Harbor and the Saugus River. The timber bulkhead along the harbor, which is about 50 years old and a mile long, was severely overtopped and damaged in the blizzard of '78. The bulkhead supports the landfill for the harbor's industrial and commercial development. In 1978, tide waters overtopped the bulkhead and flooded areas up to three or four feet deep, including the Lynnway which serves one of the City's major business districts.

"...Several solutions were explored and one in particular, would benefit the communities of Lynn, Revere, Saugus and Malden. A tidal barrier with a navigation gate across the Saugus River connecting to shore protection in Lynn and Revere would eliminate tidal flooding problems for over 2300 homes and businesses in these communities. The City of Lynn is strongly supportive of projects to prevent tidal flooding and will provide whatever assistance needed to expedite a solution." Antonio J. Marino, Mayor, City of Lynn. (Dec 17, 1985)

LYNN CONSERVATION COMMISSION

In Lynn, the effects of unusually high water in the Saugus River are not confined to the areas immediately bordering the river. These effects also can be felt throughout a considerable part of the city -- via Strawberry Brook to Flax and Sluice Ponds, and in turn to the brooks and streams feeding into the ponds. In short, the impact of Saugus River flooding can extend virtually as far as Lynn Woods. Paul A. Petrowski, Chairman. (Dec 17, 1985)

CITY OF MALDEN

MAYOR OF MALDEN

"...I support this investigation and look forward to working with the Corps of Engineers to develop a project to protect our residents from coastal flooding." Thomas A. Fallon, Mayor. (Aug 2, 1985)

MALDEN CONSERVATION COMMISSION

"...The commission appears to lean towards Option 3, the Comprehensive Plan, which includes the tidal barrier. A proposed pumping station would be extra protection. The marshes in the Saugus and Pines River estuaries could be useful as natural storage areas for interior runoff. The Commission is in favor of any planned studies of the flooding problem which help bring about a positive solution, especially in the Town Line Brook and Linden Brook areas, which would greatly benefit the City of Malden." Charles V. Maccario, Chairman. (Feb 10, 1986)

MALDEN PLANNING

"...Please be advised that the city of Malden supports any project which will reduce the threat of coastal flooding to the city...Our chief concern, besides the protection of existing structures within the 100 year floodplain, is the ability to develop the 10± acres of land remaining vacant within the area now in danger of flooding have three other general concerns which do not relate to Malden's location within the watershed, but which I feel are important enough to air here. First, any work in this area should include the total removal of the gravel deposited on the marsh for the failed I-95 extension...Second, there has been no mention to my knowledge of the potential shoaling problem which will undoubtedly result if the flood gates significantly narrow the mouth of the river...Finally, much has been printed lately about the potential for rising sea levels due to the greenhouse effect. What will be the life expectancy of this project if these predictions prove accurate?" Alfred L. Thurlow, Principal Planner. (Apr 8, 1987)

CITY OF REVERE

"...Re: City of Revere, Point of Pines Flood Protection Plan."

"...This important flood protection plan was initiated as a result of flood damages sustained during the "Blizzard of 78". The City of Revere has long been committed to this plan and has sought every available option in an attempt to secure State funding to assist in the cost sharing of this project. The current financial demands placed on the delivery of basic City services under the guides of proposition 2 1/2 however, has inhibited any attempts to exercise local funding initiatives for this project. Unfortunately, the City of Revere is unable to commit to the funds necessary to bear the local cost sharing of the project."

"...As it has been indicated in previous correspondence with the Corps of Engineers, a comprehensive flood protection plan which combines the flood protection measures proposed for the Point of Pines area with the regional flood gate plan would be strongly supported by this office. The inclusion of the Point of Pines area into the Regional Floodgate Plan is essential in assuring complete protection on a regional level. Also, this effort represents the final opportunity to provide flood protection to the Point of Pines. The City of Revere will pursue funding assistance from the State and request the State sponsor of the regional plan to share the costs in an effort to off-set the impacts associated with siting the regional flood gate structure adjacent to the Point of Pines."

"...A comprehensive flood protection plan which is tied with floodgate alignment #2 would provide the highest protection to the Point of Pines. Saugus River and Tributaries and is recommended by this office." George V. Colella, Mayor. (Jun 10, 1988)

RE: Point of Pines Section 205 Flood Protection Project, Revere.

"...It is the City's strong feeling that the current status of the Point of Pines Flood Protection Plan should not be jeopardized in the face of the City's present financial position. Because of the close association and link with the back shore plan for the Saugus River and

Tributaries...Since the tidal flood gate plan would invariably impact existing flood protection measures along the Point of Pines shoreline, it would appear feasible to expand the scope of this plan to include the Point of Pines area. I would appreciate a meeting with Corps representatives and City staff to discuss this proposal in greater detail with the view that a more comprehensive plan can be attained effecting the Point of Pines, Saugus River and Tributaries." George V. Colella, Mayor. (Jan 7, 1988)

"...I am writing in support of the U.S. Army Corps of Engineering continued efforts in developing a flood damage reduction study for the Saugus River and its tributaries. This vital project is necessary to rectify flooding in the Revere Beach Backshore areas." George V. Colella, Mayor. (Mar 23, 1987) (Also see Mar 25, 1986 letter)

"...Today marks the 4th anniversary of the "Great Blizzard of 1978", and as the seas appear calm on this day, the memory remains strong in the minds of many who saw the full force of the Atlantic Ocean engulf their property four years ago. Although this was an event that will never be forgotten by those who endured it, the effort of the Army Corps of Engineers, remains, for the residents of the City of Revere, the only glimmer of hope for protection against a re-occurring event."

"...I cannot stress strongly enough our support of these study efforts and our desire to see them proceed without delay...The shorefront property owner who has suffered through three major flooding episodes in the past ten years, cares little for studies but seeks to witness real protective measures; he looks back over the past 12 years of reports and wonders when construction will take place that will secure his life and his property. He knows that only the federal government has the resources necessary, but he wants to know when it will happen. For these reasons, I reiterate out total endorsement of the Corps' recommendations and urge that everything possible be done so that these efforts can proceed immediately." George V. Colella, Mayor. (Feb 8, 1982)

"...The City of Revere requests that the Army Corps of Engineers undertake a study to investigate flooding conditions and to determine the economic feasiblity of constructing a flood control project in the Revere Beach section of the City. Should the Corps concur with our request, the City would provide assistance in carrying out the project." George V. Colella, Mayor. (Oct 23, 1978)

REVERE CONSERVATION COMMISSION

"...I totally support a Flood Protection Plan such as the Floodgate alignment #2, that would provide a high protection of the Point of Pines and will not effect the Saltmarshes that provide feeding, spawning, and nursery habitats for finfish and shellfish." John R. Marino, Member. (Jul 12, 1988)

"...Although this was only a preliminary conference and more details would be needed, the consensus of opinion of our board is that the levee proposal was the most feasible and least damaging to the marsh, while still providing needed protection for the residence of the area. The least liked suggestion by our board was the tide gate located parallel to the General Edwards Bridge. We feel this may cause damage to Revere residence in the Point of Pines area. Of course we realize that much planning and information would be necessary for us to reach a final decision, and we are keeping an open mind to all the proposals plus any new ideas you may have." Joseph A. LaValle, Chairman. (Jul 2, 1986)

PINES RIVERSIDE ASSOCIATION

"...We would ask that the Corps please look upon the A.C.E.C. designation favorably and do all in your power to make your projects work within the designated area if it should become so. We feel that both the Corps projects and the designation are equally important and we want them both, we do not want to be forced to choose between them."

Elaine Hurley, President. (Jun 26, 1988)

"...I've found the Regional Protection Plan (option 3) to be far superior over the Local Protection Plan (option 1). The Regional Plan offers the least harm to the wetlands and allows the natural beauty of the shore to be free from walls and dikes...I strongly feel the Regional Plan is the solution and that all energy should be expelled in this direction." Elaine Hurley, Vice President. (Mar 5, 1987)

"...Our Association would like to suggest that your department include in the final project design a flood erosion prevention section for Mills Avenue of Revere. This particular area suffers from seasonal flooding and constant erosion problem. Our organization would be in favor of a revetment and wall that would still give area residents access to the beach area." Mary C. Duffy, Corresponding Secretary. (Apr 11, 1981)

REVERE BEACH CITIZEN ADVISORY COMMITTEE

The Revere Beach Citizens Advisory Committee is of the opinion that Option 3 would be the most encompassing of the projects presented at the M.E.P.A. scoping meeting. The concerns are the tidal effects when the flood gates are closed, on the seaward neighbors. We realize the cumulative effects upon the flora and fauna will only be known through further studies. The Committee would hope that stringent regulations would not allow ruinous development to take place after the flooding is controlled. The Marsh area is the basis for many life forms, once lost it can never be replaced. Ellen Haas, Chairman. (Apr 13, 1987)

OAK ISLAND RESIDENTS ASSOCIATION

"...It is our opinion that Option 3, the Regional Saugus River Floodgate Plan, is the most acceptable of the options presented. However, two areas not addressed in the plan are of concern to us.

First actual control of the floodgate could have a serious impact on the success of the plan. We believe that inappropriate timing in opening or closing of the floodgate could cause adverse repercussions in our area. The resulting flooding could be much more severe than that which would be incurred without the floodgate. Therefore, it is imperative that the matter of control be clearly addressed in the plan. Our second concern relates to the impact of the plan on the salt marsh. Too many individuals and organizations perceive the value of wetlands ceases with flood control. We believe wetlands are important for their value as a breeding ground and sanctuary for fish and other wildlife and should be preserved for that reason. The installation of the floodgate could, in our opinion, increase pressure to fill and develop wetland areas. Unless some assurance could be given that this area would be safegarded from the danger of development pressure, the plan would not be acceptable." Oak Island Residents Association. (May 27, 1987)

POINT OF PINES YACHT CLUB, INC.

"...As we also discussed, we currently contend with approximately a 5 - 6 knot current. The Yacht Club requests if this condition could be improved (diminish current 2 - 3 knots) without compromising the flashing of the river it would be greatly appreciated. Any <u>increase</u> of current would not be acceptable. The Point of Pines Yacht Club <u>supports</u> this project and we feel confident that all our concerns will be addressed." Vincent A. Piccinni, Commodore. (Jun 28, 1988)

POINT OF PINES

"...We are opposed to the construction of a floodgate on the Point of Pines Beach, Revere, MA, or contiguous to it. The Point of Pines Beach on the Saugus River has two qualities which are rare, if not unique, in this area. It consists of fine granular, soft sand. Because of past channel dredging the river at this area provides the only swimming at low tide. Since the beach is small the loss of the amount necessary to accommodate a floodgate would be unacceptable. The loss of any part of this beach would seriously diminish the quality of life here. In addition the floodgate itself would exacerbate the congestion problems of the Point of Pines. We fear it would become an attraction to fishing, loitering and late night partying and add to parking problems." Bernard Blume, Sylvia Blume. (Jul 7, 1988)

TOWN OF SAUGUS

TOWN MANAGER

"...I would like to offer the Town's wholehearted support in this project. We are particularly interested in the phase shown in the presentation as the Regional Saugus River Floodgate Plans which offers the most protection for a larger number of businesses and homes." Norman B. Hansen, Temporary Town Manager. (Mar 9, 1987)

"...I am pleased that the Coastal Flood Protection Study, which I formally requested, will be resumed. I understand that flood protection may still be a possibility for the hundreds of homes and businesses in Saugus flooded in the Blizzard of 1978." Paul T. Rabchenuk, Town Manager. (Apr 23, 1985)

"...In the blizzard of 1978, several hundred homes and businesses experienced tidal flooding in the Bristow St. and Ballard St. areas of Saugus. I would appreciate the Corps initiating an investigation for solutions to our flooding problem." Norman B. Hansen, Temporary Town Manager. (Sep 9, 1981)

BOARD OF SELECTMEN

"...Please be advised that the Saugus Board of Selectmen has voted to request that the Army Corps of Engineers study the feasibility of breaching the I-95 sandpile in conjunction with the proposed floodgate construction and are particularly interested in how such a proposal would enhance the viability of the existing marsh, what effect such a proposal would have on flood control, wildlife and mosquito control." Peter Manoogian, Board of Selectmen. (Jun 27, 1988)

"...At a meeting on March 15, 1988 the Board of Selectmen voted to go on record as in favor of Option 3 of the Saugus River Flood Gate Plan as presented by Mr. Hunt of the U.S. Army Corps of Engineers." Joyce Villani, Clerk, Board of Selectmen. (Mar 22, 1988)

SAUGUS CONSERVATION COMMISSION

"...Clearly the most viable option is number 3, Regional Saugus River Flood Gate Plan. Not only does this plan disturb less wetland area and leave the banks of the Saugus River undisturbed, it affords protection to a far greater number of homes as well as the upper reaches of the Saugus River, particularly the Shute Brook area. I have presented a brief summary of the study to the members of the Saugus Conservation Commission. There are some concerns which the Commission feels should be addressed in any environmental study done for the project. 1. What effect will entrapment of fresh water run-off have on the delicate ecology of the saltmarsh while the gates are closed during storm surges and peak high tides? 2. Because of the potential for increasing development in this resource area by a lowering of the flood level designation, the Commission would strongly urge the undeveloped flood-plain be protected, possibly through land-taking by eminent domain. 3. Exploration of the possibility of utilizing the water power produced during uses of the floodgates" Anne Cyros, Commissioner and Frank McKinnon, Chairman. (Mar 30, 1987)

SAUGUS ACTION VOLUNTEERS FOR THE ENVIRONMENT

"...The Saugus Action Volunteers for the Environment (SAVE) give conditional endorsement to the Floodgate Control option described in the study. It is our feeling that this floodgate proposal would be the least environmentally destructive and the most aesthetically pleasing of the various options studied by the Corps. It would also improve the quality of life for a large number of home owners in Saugus who now constantly live in the fear of major flooding whenever a large storm hits our area.

The major concern we have is the possible effect this plan might have on the adverse development of the valuable marsh area behind the proposed flood control structure in Saugus and Revere, and in the Saugus River Basin. Since this is the largest relatively unspoiled marsh area left, north of Boston, and since it is so important, ecologically, for both fisheries and migratory water fowl, we hope that ultimately a joint Federal-State-local consensus will be reached to preserve these valuable wetlands from the threat of development. It is our hope that the Saugus Action Volunteers for the Environment can give full endorsement to the proposal of the Corps of Engineers when the specifics of your plans are completed. Ellen Burns, President. (Apr 6, 1987)

SAUGUS RESIDENTS

"...We, the residents of the lower Shute Brook area, would like to support the floodgate control option for the Saugus River over the levee alternative for lower East Saugus. Large amounts of rain coinciding with high tides cause the brook to backup to the west of Central St. According to one of your staff engineers, the use of flood gates on the Saugus River during high tides in a high rainfall period e.g. (hurricane) would alleviate the tidal influence on Shute brook and therefore greatly reduce the potential severe flooding for our area. Therefore, please consider the residents along Shute brook when you make the final decision." Richard Mytkowicz. (Oct 27, 1986)

INTEREST GROUPS

MASSACHUSETTS AUDUBON SOCIETY - RESOURCES FOR THE NORTH SHORE

"...The Massachusetts Audubon Society is most concerned that the proposed damage reduction program for the Saugus River and its tributaries has the potential for severely impacting the Saugus and Pines River Estuary. Any flood control program which results from this study must make every effort to ensure that the integrity and productivity of the estuary not to be compromised. While we recognize the occurrence and seriousness of tidal flooding in target communities, it is critical, too, that the inappropriateness of the existing and proposed development within the floodplain be recognized...All parties involved in, or concerned with this project have highlighted the importance of the Saugus and Pines River Estuary. It is on the EPA priority wetlands list. The Conservation Commissions of many abutting municipalities are actively interested in increasing the protection afforded the marshes. The Massachusetts Audubon Society urges that the protection and enhancement of the estuary be considered in all phases of this project." Richard K. Quateman, Director. (Apr 10, 1987)

MASSACHUSETTS ASSOCIATION OF CONSERVATION COMMISSIONS

"...MACC represents the 350 conservation commissions of the state which are empowered to take action under the state Wetlands Protection Act, a law designed to protect all the interests connected with wetlands, floodplains, banks, land under waters and associated fisheries and wildlife. Under this law, the policy is to prefer solutions which have the least impact on the resource. Specifically, a waiver is required from the commissioner of DEQE for any action altering more than 5000 square feet of wetland. Such a waiver is not available if dealing with raising or moving the dwellings along the river, is available, we do not believe that such variance can legally be granted. Your Options #1 and 3 would have disastrous effects on the river and estuary, from what we have heard. Such solutions simply encourage more development. This is not the modern approach, and we are opposed to it." Alexandra D. Dawson, Presiden. (Feb 3, 1988)

"...At the outset I should like to state that an alternative which would destroy more than thirty acres of vegetated wetlands and an equal or larger area of tidal flats is unacceptable and should be dropped from consideration so that time and money are not spent on further study...The United States Environmental Protection Agency has already indicated its concern for this estuarine area by placing the Saugus River wetlands on its priority list of wetlands. The Commonwealth of Massachusetts should also take protective action by placing this area under the Wetlands

Restriction Program and designating it an Area of Critical Environmental Concern. As an alternative to no action, recognizing the concern of citizens for protection from flooding, a more serious consideration should be given to Option 2, floodproofing of structures, as well as a program to eliminate substandard structures, discourage, really discourage, further building in the flood hazard area." Judith C. Skinner, Member, MACC Board of Directors. (Apr 12, 1987)

"...This massive project will severely degrade wetlands and coastal resources, whether Option 3 or Option 1 is chosen. It is not state policy to destroy these resources in order to encourage further development of areas that should never have been developed. The EIR must include analysis of federal EOs that limit federal projects affecting wetlands and floodplains. SEND US A DRAFT EIR, Alexandra Dawson, President. (Mar 30, 1987)

SWIM - NAHANT CITIZENS COMMITTEE FOR SAFER WATERS IN MASSACHUSETTS

"...I would like to reemphasize the potential the project may have for making additional development possible. The major reason that the marsh area is not totally developed at the present time is that they flood periodically. Once flooding is prevented, a tremendous amount of money and energy will go into ways to circumvent the weak and often unenforced laws that protect the wetlands. However, all this said, I was really delighted to hear about your plans for making protection of "a major portion of the estuary" an important portion of the Saugus River Floodgate Project. I will be watching in the Saugus floodgate plans for information about how the decisions will be made on how often to close the Saugus floodgate and for proof that there will be no interference with the free flow of water into and out of the estuary.

"You will only get support of the environmental community for this project if there are <u>guarantees</u> that the estuary will be protected... protected from development and protected from ecological damage. In the early hearings, it was pointed out that the Corps couldn't save the marshes by itself, and one of my major purposes in writing the article for the Massachusetts Association of Conservation Commissions was to alert the environmental community not only to the problems but also to the need for cooperative effort in giving the marshes strong protection if the floodgate is indeed built.

"I will continue to help increase public awareness of the Saugus River Floodgate Project. Although our viewpoints may not always coincide, I am sure the more the public knows about the project the better it will be in the long run. I'm looking forward to serving on the Technical Advisory Group. Polly Bradley, President, Nahant SWIM. (Nov 30, 1987)

"...SWIM,...is very much concerned about the protection of the Saugus-Revere marshes, which are the nursery for many marine species important to the commercial and recreational fishing vital to the Town of Nahant. The proposed Flood Damage Reduction project for the Saugus River and tributaries could lead, directly or indirectly, to damage to the marshes, and we urge that you consider these potential damages in the scope of the National Environmental Policy Act study. As an integral part of the study, protection of the marshes must be considered. There are developers ready to build immediately, once the marshes are no longer subject to flooding, and therefore strong - powerful and effective - protection of the marshes must be built into the project itself." Polly Bradley, President. (Jun 11, 1987)

"...The Saugus-Revere marshes serve as a nursery and source of nutrients for the valuable fish and shellfish industry in Nahant. After the sewage of the North Shore and Boston is adequately treated, SWIM expects that the shellfish will again be edible and the fish will no longer live lesions and fin rot, provided additional pollution can be avoided. What will the effects be of the Flood Damage Reduction Project upon the ecology of the salt marshes, Lynn Harbor, and Broad Sound?...This proposal would encourage building on a barrier beach, on tidelands and in the flood plain. What will be the effects of this additional construction upon the ecology of these areas and upon the sewage treatment plants now being planned for Boston and the North Shore?...that the scope of study include long term effects on vegetation, other biological systems, flood hazard areas, geologically unstable areas, solid waste, and community/housing and the built environment." Polly Bradley, Secretary. (Apr 15, 1987)

"...I am very much concerned about the effect of this project upon the Saugus and Revere marshes. As you know, marshes are nurseries for fish and shellfish, and the economic value of salt marshes is higher than the richest of farmland. Damage to the Saugus-Revere marshes will also cause damage to the ecology of Lynn Harbor and Broad Sound, which are valuable lobstering and fishing grounds. The clam flats of Revere, Lynn, and Nahant will once again provide excellent shellfishing after the Lynn-Nahant-Saugus sewage treatment plant is built, provided the clams are protected from pollution by other projects. I am concerned about the potential effects upon the 1400 acres of salt water estuaries behind the gates and the many acres of fishing, lobstering, and shellfishing grounds which are richer because of the nutrients and the nursery area of the salt water estuaries.

"The design of the flood gate seems to indicate that the gate may hold back the waters and slow them down even when the flood gates are not closed...Our concern about Revere, about Lynn, about Nahant, about the entire coastal zone, grows from a deep love of the ocean and of the North Shore...

Carl and I have watched with our own eyes the destruction and damage of decades of environmentally unsound practices, but we have not given up...The Commonwealth can protect the environment. We intend once again to eat clams and flounder from the lower North Shore...we hope before our 50th anniversary celebration. Help us make it possible! In summary, I truly believe at best this project would be a waste of money and at worst could do severe environmental damage. Please do not hesitate to turn down the project entirely if the project cannot be done without ecological damage." Norma Brooks, SWIM member. (Apr 14, 1987)

CONSERVATION LAW FOUNDATION OF NEW ENGLAND, INC.

"...Among the most important impacts that must be addressed are wetlands destruction, wildlife and shellfish resources, aesthetic impacts, access, and the encouragement of further growth in the study area. Experience in other coastal communities with flood control projects should be discussed with respect to encouragement of further growth.

"The indirect wetland impacts of Option 3 should be examined in detail. The "initial finding" that water level and water quality changes resulting from flood gate closure will have "negligible impact" should be closely scrutinized. The ENF pays scant attention to nonstructural alternatives to Options 1 and 3. Such alternatives must recieve much greater consideration in the draft EIR. The draft EIR should spell out the possible elements of a successful nonstructural control plan, and not simply discount the concept as impractical." Paul Hauge, Staff Scientist and Sally Newbury, Legal Services Attorney. (Apr 15, 1987)

ADDENDUM 2

SHOREFRONT INVENTORY

REVERE BEACH BACKSHORE - SHOREFRONT

A. Shorefront Inventory

In 1986 Vollmer Associates accomplished an inventory of a major portion of the study area shoreline including all of the Lynn Harbor Shorefront, along the Saugus River in Saugus and in Revere the reach from the Gen. Edwards Bridge to Fowler's Marina. The remaining shoreline was accomplished by the Corps. The criteria established for evaluating the shoreline's replacement costs, useful life after replacement and O&M cost is summarized as follows:

Type Structure	Replacement Cost ($ per foot)	Useful Life After Replaced (Years)	O&M Cost (% of Replac. per year)
Rip Rap	$ 70 to $ 260	50 yr.	1%
Walls	$370 to $1700	30 yr.	1%

The cost of these structures varies depending on size and location. The replacement schedule and costs were developed by location, total length of structures and by their severity of deterioration. Schedules were developed with and without the LPP Projects and Regional Plan.

The year of replacement varied depending on the existing condition and type of structure. Severely deteriorated walls with over 25% of their length showing failure were assumed to be replaced in 10 years, about 1996, while severely deteriorated rip rap or dunes would be replaced 10 years after 1996. The year 1996 was assumed to be near the completion year of a Federal project which would affect a revised replacement schedule. Until 1996 there would be no difference in replacement schedules with or without a Federal project.

Structures showing moderate deterioration with failure of 10-25 percent of their length were assumed to be replaced 20 years after 1996 for rip rap and 10 years after for walls.

Lightly deteriorated structures with less than 10% of their length failing would be replaced 30 years after 1996 for rip rap and 20 years after for walls.

The Maintenance cost was assumed to increase each year at a rate of 0.1 percent due to accelerated deterioration from three coastal storms per year causing wave damage, salt water corrosion, undermining of foundations and erosion behind or through the structure. Also overtopping of structures would cause damage directly or failure from a surcharge loading of water or saltwater soil. Sea level rise at a rate of 0.1 foot per 10 years would require an increase in the size and height of structures, increasing the replacement cost by 1 percent for every 10 years between replacements. That is after 30 years a wall would cost 3 percent more to construct at the 1986 price level with a 0.3 foot rise in sea level.

It was assumed any existing vertical bulkhead would be replaced by a steel sheet pile wall since this appears to be the common practice. Although low cost rip rap and severely eroded embankments were assumed to be replaced in the future by built up embankments with rip rap this may not by the case. The environmental loss associated with this type of wide structure may be strongly discouraged in the future. At least one developer has recently run into permitting problems with this replacement. Thus higher costs may result in the future in this A.C.E.C. area requiring rip rap slopes replaced with less environmentally damaging walls. Piers are assumed to have a useful life of 40 years and decks 20 years based on information obtained by Vollmer Associates. The total replacement cost was estimated at $170 per SF with decks at $10 per SF and O&M costs were increased at a rate of one percent per 10 years as explained for shorefront structures.

The replacement year for piers was assumed that 25 percent of piers would be replaced each ten years. Over a 22 year period the length of piers increased by 3445 ft. about 57 percent based on a comparison of 1974 and 1986 aerial photographs. It was therefore assumed piers would continue to increase at a rate of 157 feet per year due to the strong demand for recreation boating in the area. The designation of the area on August 23, 1988 as an Area of Critical Environmental Concern (A.C.E.C) may actually slow down the growth of piers and recreation boating development just as it may increase the use of walls. The estimates have not been revised to reflect this change. It is believed a more conservative estimate of costs is reflected in this approach. If replacement of shoreline structures were adjusted due to ACEC designation a slower growth in piers with an increase use of walls would result in a net increase in costs.

WITH THE PROJECT (REGIONAL PLAN)

A number of basic assumptions were made with the Regional Plan.

. Where shorefront structures along Lynn Harbor and Point of Pines are replaced by new structures as part of the Regional Plan, future without a project replacement costs would be a benefit to the Regional Plan. This is because their future cost and maintenance were eliminated by the Regional Plan and are now included in the Regional Plan's costs estimates.

. For all other shorefront structures, around the estuary the Regional Plan would hold tide levels at lower levels, no longer requiring the structures to be as high and wide. It was assumed replacement and therefore maintenance costs to be reduced by 10 percent. For example a 5 to 10 foot high wall or dike could be rebuilt 1 to 2 feet lower. That is, storm tides generally reaching EL. 9 (every 10 years) would be held to about EL.7 during coastal storms.

. By eliminating storm tides from overtopping and damaging shorefront structures, there estimated replacement interval would be increased by ten years. This was felt to be a minimum increase since historical information along Revere Beach over 100 years showed that walls subject to storm overtopping, undermining and daily wave action caused shorter lives of walls by as much as 40 years.

. The initial replacement of walls or rip rap was assumed delayed ten years after the Regional Plan is built since owners would no longer experience the problem of storm overtopping structures, the deterioration rates would slow down, and they would delay the decision to replace and repair their shorefront.

The Local Protection Projects deleted replacement costs (a project benefit) along their alignments since their LPP cost estimates included new structures with maintenance costs. The replacement costs and benefits with and without the projects (LPP's Regional Plan) are shown on Table 27.

The replacement costs are summaries of the more detailed analysis.

Lynn includes:

1. Lynn Harbor features replaced or repaired by shorefront plans.
2. Along the Saugus River where LPP alignments (J-P) were evaluated. Under the Regional Plan, the cost of replacement and maintenance is reduced (10%) and replacement life extended 10 years.
3. Other areas in Lynn along the Saugus River with and without the Regional Plan. (Under the Regional Plan, same as Item #2.)

Revere includes:

1. Structures replaced at Point of Pines with the Regional Plan.
2. Structures along the Pines River - Riverside to Revere St. (LPP alignment G-J) with and without the Regional Plan.
3. Structures along the Town Line Brook LPP alignment.
4. Other shorefronts in Revere including the Pines and Saugus River and Marsh, Northgate, Route 107 and B&M railroad.

Saugus includes:

1. Along the Saugus and Pines Rivers where LPP alignments were evaluated.
2. Other shorefront in Saugus including along the Pines and Saugus Rivers, Route 107 and railroads.

Piers include existing and potential piers along the Saugus and Pines Rivers in Revere, Lynn and Saugus.

Sensitivity Analysis for Shorefront Benefits

The most sensitive assumptions made in the analysis are the unit costs for replacement and the extended life of the structures, i.e. 10 years with the Regional Plan.

A unit costs for replacement of these structures are assumed conservative. The costs are a low estimate and do not include many ancillary costs, for example: replacement of material behind the walls or dikes, removing existing structures, relocation of utilities, design costs, permit costs, shut down or delays of roads or businesses during construction, mitigation of impact cost and alterations in drainage systems.

The range in potential costs which could have been used, as found in the study are:

(1) for rip rap or stone-faced dikes embankment, the cost could range from a low of $500 per foot as estimated along the Pines River to a high of $1300 per foot in Lynn Harbor (as opposed to $70 to $260 used); and
(2) for walls, the costs could range from $1000 per foot for a five foot wall on land to $2000 per foot at the edge of the Saugus River, or $2500 per foot in Lynn Harbor (as opposed to $370 to $1700 used).

The costs per foot and increase in structural life used in the analysis are believed to be conservatively low; the conservative approach was used so as not to overstate the benefits.

TABLE 27

SHOREFRONT BENEFITS
('86 Price Level)

Location of Structures Affected by Plans	Length of Shoreline Structures (feet)	Estimated Cost of Replacement ($1000)	Existing Annual Cost of Replacement & O&M ($1000)	Reduction in Annual Cost: Regional Plan Benefit ($1000)	Reduction in Annual Cost: LPP Plan Benefit ($1000)
Lynn Harbor	7,930	$ 5,500	$ 252	$ 252	$ 252
Lynn Saugus River (LPP)	12,450	3,161	141	86	13
Lynn Saugus River (other)	6,950	1,912	61	36	0
Lynn SUBTOTAL	27,330'	$ 10,573	$ 454	$ 374	$ 265
(1988 P.L.)	-	($ 11,038)	($ 474)	($ 390)	($ 277)
Revere-Point of Pines	3,950	$ 1,889	$ 99	$ 99	N/A
Revere-Pines River (LPP)	12,550	979	36	22	36
Revere-Town Line Bk (LPP)	1,300	338	16	9	18
Revere-Other Areas	37,320	5,888	305	185	0
Revere Subtotal	55,120'	$ 9,094	$ 456	$ 315	$ 54
(1988 P.L.)	-	($ 9,494)	($ 476)	($ 330)	($ 56)
Saugus (LPP)	9,850	1,434	70	43	14
Saugus-Other Areas	54,890	11,105	315	191	0
Saugus Subtotal	64,740'	$ 12,539	$ 385	$ 234	$ 14
(1988 P.L.)	-	($ 13,091)	($ 402)	($ 245)	($ 15)
Total Structures	147,190'	$ 33,623	$1,352	$ 965	$ 346
(1988 P.L.)	(28 miles)				
Piers-along Rivers	9,500'	$ 21,376	$1,171	$ 667	$ 0
(1988 P.L.)	-	($ 22,317)	($1,223)	($ 695)	0
Total Shorefront:	156,690	$ 55,940	$2,575	$ 1,660	$ 346
(1988 P.L.)	(30 miles)	($ 56 M)			

ADDENDUM 3

Revere Beach Stability
and Analysis Discussion
with Dr. Bohlen, Consultant

The University of Connecticut

AVERY POINT
GROTON, CONNECTICUT 06340
COLLEGE OF
LIBERAL ARTS AND SCIENCES
Department of Marine Sciences

June 15,1983

Mr. Robert Hunt
U.S. Army Corps of Engineers
Bldg 112N
424 Trapelo Road
Waltham,Massachusetts 02254

Dear Bob:

As requested I have reviewed the enclosed minutes of our April 4,1983 meeting/workshop on Revere Beach. The minutes appear accurate and I have simply made a few marginal notes. I believe that all of the issues outlined are covered in my report which was forwarded to you last week. Hopefully by now you have had a chance to review it. If there are any questions don't hesitate to call.

One item that appears in the minutes and is only briefly mentioned in passing in the report is the matter of beach maintenance. As accurately indicated in the minutes I feel that for renourishment to represent a long-term solution to flooding and the like at Revere Beach a committment to maintenance must be made by the MDC and the Corps. I recognize the difficulties associated with implementation of any long-term committment such as maintenance but given the nature of the transport field affecting the beach some degree of grooming and renourishment must be annually budgeted to insure continuing protection from storm associated overtopping. Such an item should be part of any long-term plan.

Again, if there are any questions don't hesitate to call.

Sincerely,

Frank.

W.Frank Bohlen
Associate Professor

WFB:ep

Dr. Bohlen

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGO.

Reviewed by W.B.

REFERENCE OR OFFICE SYMBOL	SUBJECT		
NEDPL-BC	Revere Beach Meeting with Dr. Bohlen		
TO	**FROM**	**DATE**	**CMT 1**
Chief, Planning Division	Project Manager	2 June 1983 HUNT:kab:546	

1. On 4 April 1983, a meeting was held at NED from 1000 to 1600 hours to discuss Revere Beach with Dr. Frank Bohlen, hired by the Corps for consulting services. The following attended the meeting:

- W. Frank Bohlen, PhD., Oceanographer Marine Sciences Institute, Avery Point, Groton, Connecticut
- Henry Higgott, Project Manager, Revere Beach Reservation, MDC
- Frank Stringi, Assistant Director, Dept. of Planning & Community Development, Revere
- Joseph L. Ignazio, Chief, Planning Division, Corps of Engineers
- Robert G. Hunt, Project Manager, Revere Beach Backshore Study, Planning Division, Corps of Engineers
- Joseph A. Bocchino, Project Manager, Roughans Point, Planning Division, Corps of Engineers
- Thomas C. Bruha, Chief, Beach Erosion Unit, Planning Division, Corps of Engineers
- Cathy O. LeBlanc, Beach Erosion, Planning Division, Corps of Engineers
- Jim Blair, Foundations and Materials, Engineering Division, Corps of Engineers
- Robert LeBlanc, Design and Estimates, Engineering Division, Corps of of Engineers
- Tony Riccio, Coastal Engineering, Engineering Division, Corps of Engineers
- Bill Colcman, Coastal Engineering, Engineering Division, Corps of Engineers
- Ray Francisco, Coastal Engineering, Engineering Division, Corps of Engineers

2. A report from Dr. Bohlen is forthcoming discussing the issues at the meeting (attached are handouts at the meeting).

3. Critical issues and discussion points follow: (comments were provided by BMB, CDB and DB-Coastal).

a. The Crescent Beach seawall in Reach A (1955 ft.) was not significantly overtopped in 1978, nor does the runup analysis show overtopping for any event based on existing profiles. Based on the history of this reach since 1900 (i.e., building up with sand over the years), the beach is not expected to erode over the next 50-100 years to allow overtopping.

b. The Wonderland seawall in Reach B (4105 ft.) is overtopped with frequent tide events and the beach is severely eroded due to wave refraction, beach migration and possibly a groundwater seepage problem. High short term erosion rates (i.e. 20,000± CY/year) have occurred in the past. If the beach is properly restored, maintenance rates should not exceed this level and should be lower.

Says that
See comments on restoration - to wit seawall etc.

DA FORM AUG 80 2496 PREVIOUS EDITIONS WILL BE USED

NEDPL-BC 2 June 1983
SUBJECT: Revere Beach Meeting with Dr. Bohlen

c. The seawall in the Oak Island Street area, Reach C (5240 ft.) was not significantly overtopped in 1978 nor does the preliminary runup analysis show potential overtopping for any future tide event, based on existing beach profiles. Based on past history of beach accretion and existing geometry, the beach is not expected to erode to the point of allowing overtopping over the next 50-100 years, even though the location may be more dynamic than Reach A. (A review of the runup analysis and wave refraction will be accomplished in the final planning stage to substantiate the preliminary findings).

d. The seawall along the North Beach Reach D (2380 ft.) was overtopped along 1500 feet of concrete steps in 1978 and further tide events are expected to overtop the wall due to the eroded beach.

e. Based on current findings, no additional measures are needed to assure flood control along Reach A and C.

f. Potential beach options include:

(1) Recreation beaches with a minimal elevation of 9 ft. NGVD, 100 foot wide berm and 1:15 slope.

(2) Flood control beaches should be built with the top of berm at least one foot above the design stillwater level (SWL), preferably two feet above the SWL, depending on economics. The berm should be no less than 100 feet wide after sloughing off from the 1:15 slope.

(3) Beach slopes will probably slough off naturally to say a 1:50 construction profile. The beach for Reach B should be feathered further along Reach A and C than estimated to retain the natural contour or curvature of the beach so to maintain the natural angle of wave to beach. This should reduce maintenance. Ideally, building up all reaches A to D the same is preferred but not absolutely necessary, i.e. B may be built up alone, feathered into A + C.

(4) Erosion rates for restored beaches should be based on modeling and wave refraction analysis and not on historic rates.

g. Options considered less acceptable than beach restoration are: raising walls, rock revetments, and breakwaters, because of aesthetics and safety. (The cost effectiveness and impacts of these options are being evaluated).

h. Restoration of Lynn Beach should be investigated since bank-run sand from I-95 has blended well. Contact Al Ferillo at MDC for sand samples. Color should not be a problem with bank run sand. Public involvement is needed to determine acceptable color. I-95 sand needs to be tested for properties. — SEE COMMENTS ON [illegible] [illegible] OF SAND.

i. Potential freezing of beach sand in 1978 was not expected to be a factor in limiting erosion in Reaches A and C. Runup would have thawed the thin frozen layer out quickly and the blocks of ice which washed over wall in B normally would have contributed to beach erosion from the pounding of the blocks on the beach.

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j. The groundwater seepage problem warrants further investigation to determine impact on beach erosion and the need for corrective measures before a beach is built in B.

k. Deposition of eroded (restored) beach sand in navigation channels and on Lynn Harbor shellfish beds and duck wintering areas is highly unlikely. The velocity of flows from Saugus River through channels and around Point of Pines prevents buildup in channels and migration of sand across the river to Lynn Harbor. This is why Point of Pines beach is building up.

l. Dr. Bohlen reported that the wave refraction analysis and data on wave heights in his report are probably the best available and more than adequate for engineering designs. (This information needs to be obtained from Dr. Bohlen).

m. If restoration is accomplished, recommend a good monitoring program for migration.

n. Overtopping of the Reach B seawall occurs with such turbulence that a secondary seawall at the toe of the park embankment option would be a safeguard to prevent erosion at the toe of the embankment.

o. The alternative to structural improvements is sandfill of a good quality designed for the desired stillwater elevation. A properly designed and maintained beach should eliminate the need for any backshore or toe protection of the existing seawalls, if it is to be used as a flood protection improvement. The problems then become either: 1) institutional, assuring funds are programmed for timely beach maintenance, or 2) the cost effectiveness of a beach vs. other options.

p. He recommends considering combinations of measures, i.e., beach plus embankment for recreation and flood control. Because of ?adequacy? of wave data, designs should be conservative.

TIDE FLAT REVERE BEACH

q. The naturally flat beach fronting Broad Sound serves as a wave reducer, dissipating wave energy before entering the area, even during the worst storm events. Deep water wave conditions cannot occur along Revere Beach due to the shallow water contours fronting the beach.

r. Aerial photos taken under good wave action may be funds well spent for analyses purposes - sand migration and wave refraction.

Robert G. Hunt

ROBERT G. HUNT
Project Manager

Incls
as

cc:
Team Members
Planning Division File
Mr. H. Higgott
Mr. F. Stringi
Dr. Boheln

To: Mr Tom Bruha
Mr. Bob Hunt

June 4,1983

U.S. Army Corps of Engineers
New England Division
Waltham,Massachusetts

From: W.Frank Bohlen PhD

University of Connecticut
Marine Sciences Institute
Groton,Connecticut

Subject: Revere Beach Backshore Study
Workshop Comments

To supplement the comments provided at the workshop held on April 4, 1983 at NED Waltham at which a variety of designs intended to reduce flooding potential along the Revere Beach shorefront were discussed, the following responses to the questions listed in the Workshop handout (attached as Appendix A) are provided:

Question No. 1. Although comprehensive, long term data detailing the surface wave field in the open waters of Massachusetts Bay immediately adjacent to Broad Sound are not available, additional effort to obtain field data does not appear to be necessary at this time. The wave data obtained by Raytheon Corp. as part of the Massachusetts Deepwater Port Study (1974) and referenced in the Revere Beach Master Plan prepared by Carol R. Johnson & Associates (1978) appear sufficient for the purposes of initial planning and design. The limitations in this area appear to be more a factor of the influence of the broad shallows fronting the beach and the associated means of adequately modeling the frictional retardation and modification of the incoming wave field induced by these shallows than inadequate knowledge of the offshore wave field. If effort was to be placed in one of these two areas it would appear to be most profitably placed in the development of accurate models of wave refraction including the effects of friction.

Question No.2 Since the more exposed conditions characteristic of Revere Beach favor increased wind and wave driven setup it appears possible that stillwater levels at this location could be somewhat higher than those concurrently observed at Boston (i.e. Commonwealth Pier). The flood level surveys conducted following the February,1978 storm seem to support this conclusion (see Tidal Flood Profile No.11 Cohasset,Mass. to Georgetown,Maine Jan.,1980 prepared by NED Waltham. Title appears to be New England Coastline Tidal Flood Survey.)

Question No.3 All available information indicates that Reach A along the southernmost limit of Revere Beach and Reach C north near the midpoint of the beach adjacent to Oak Island Street,are quite stable. The long-term average accretion observed in these areas appears to be the result of the deposition of materials transported from other sections of the beach that are concurrently experiencing erosion (most notably the area fronting the MDC Bath-house). If detailed time-series observations of beachfront profiles along A and C were available I suspect that they would show that the above accretion rates were decreasing in response to the combined effects of reduced sediment supply and advancing sea level. In the absence of mitigating circumstances (in particular an increase in sediment supply) this trend should continue. Over the next 50 to 100 years therefore, some erosion can be expected in Reaches A and C. The magnitude of this erosion however, should be small and essentially scaled to the rate of change of mean sea-level. In comparison to changes that might occur at other points along the beach or within the immediate offshore, the longterm changes in A and C are expected to be small. For at least initial design purposes therefore, it does not appear unreasonable to assume that these areas will be historically stable.

Question No.4 Observations suggest that minimal overtopping of the seawalls along Reaches A and C occurred during the February,1978 storm. This factor in combination with the costs associated with even small increases in backshore elevation and/or beachfront width suggest that sand placement along

A and C represents a relatively low priority item in comparison to placement along other sections of Revere Beach.

Question No.5 This question was discussed in some detail during the Workshop. Key points of the discussion included:

a. Selection of a design life of 50 to 100 years seems somewhat unrealistic given the state-of-the-art in the modeling of beachfront response following major renourishment. Ten to 20 years might be more realistic. With respect to the storm conditions selected for design purposes ability to withstand the 100 year storm or the events with an annual recurrence probability of 1% seems appropriate. Designs to withstand the 500 year or the SPN appear to result in a significant increase in costs. Such increases might be difficult to justify from the cost:benefit standpoint.

b. Backshore elevations along the seawall of SWL +2 or greater appear to be preferable. This would provide reasonable protection from 100 year storm conditions while providing some degree of latitude to permit readjustment during the immediate post-project period. The Master Plan called for a 1:20 slope from an elevation at the seawall of 15 ft +MSL(NGVD). Such a slope was expected to place the mean high water line during moderate storm conditions at a point approximately 115ft from the seawall. Beyond this point slopes would decrease progressively to gradually fair into the extremely shallow offshore grades. Placement of sand along the upper beach at the horizontal (as shown in the drawings included in Appendix A for Reaches B and D) may allow a slight reduction in the backshore elevation on the assumption that readjustment will see a slope develop sufficient to increase elevations along the base of the seawall while decreasing elevations adjacent to the mean high water line. The extent to which this will occur depends in large part on the grain size characteristics of the fill material. Sands coarse with respect to the prevailing materials may support such a readjustment.

As the grain size differential decreases the tendency for readjustment may also decrease leaving a situation in which upper beach slope increases only due to erosion along the high water line. Under these circumstances backshore elevations may only tend to decrease. At elevations (Immediate post-construction) approaching SWL any such decrease would cause elevations to rather quickly approach the 100 year storm level limiting runup protection and increasing the potential for beachfront erosion during high energy events. In short, keeping backshore elevations as high as possible appears advisable.

c. The utility of high backshore elvations and a reasonably wide (~100ft) beach above the mean high water line within flood control efforts depends in large part on the overall stability of the placed sands. Stability or the resistance to erosion appears to depend primarily on the character of the bounding seawall and the plan contour of the finished fill. In the area of the MDC Bath-house (Reach B) the broad concrete apron complicates sand placement and results in a situation favoring erosion due to storm wave impact along the seaward vertical face, swash return from the inclined face, and diffraction effects along the southern and northern margins. It would be preferable if this discontinuity could be removed. Since this does not appear to be feasible at this time effort must be made to "obscure" this structure as much as possible.

With regard to the plan contour of the beach, the erosion of the placed sand will in large part be a function of the angle of incidence between the incoming wave field and the seaward edge of the placed sands. At normal incidence readjustment will occur primarily via onshore-offshore transport and will vary in response to grain size/wave energy characteristics. This process is relatively slow and reasonably predictable. As wave incidence becomes progressively more oblique erosion via longshore transport will increase rapidly and tend to dominate the net displacement of fill material. To minimize this transport design contours should be selected following analysis of the incoming wave field (particularly local refraction characteristics) in combination with consideration of the prevailing stability of the beach. If the present form of the beach is stable then the design contours should as far as possible parallel the existing beach contours. The extent to which this"fairing"is possible will determine the initial stability of the placed sands. Poor fairing will result in high initial transport rates during the immediate post-project period. The final beach form will depend upon the amount of the placed sands remaining within the project area following termination of this readjustment. The goal,of course,is to maximize this retention in the project area.

The extent to which "fairing" is necessary to maximize stability determines the volumes of sand required to achieve particular contours. For a long, straight beach with moderate to high stability, sands must be added to the entire beach if initial contours are to be stable. Pocket beaches or beaches characterized by several transport cells (effectively segmenting the beachfront) may be less demanding. In the case of Revere Beach it is apparent that significant changes in the beachfront within Reach B will require a moderately large volume of sand with the materials faired from the Crescent Beach area north to the vicinity of Oak Island Street. Smaller volumes of sand simply placed in front of the MDC Bath-house will experience high initial erosion rates and will be transported north and south away from the deposition site. The ultimate contour will most probably be little different than that presently prevailing. With regard to questions concerning the need to continue fairing beyond the Oak Island area, Although it is always preferable to consider the entire beach as a single unit and sand accordingly, it does not appear essential in the case of Revere Beach. This area is affected by several transport cells. The A,B,C Reach appears to constitute one of these cells. As a result the confinement of sanding to this area appears justified. It should be recognized that this construct is to some extent conjectural despite being based on the best information available. As a result if it is essential that sands placed along the southern Reaches not influence areas to the north additional data concerning the character of sand transport along Revere Beach should be obtained.

Question No.6 "Reasonable erosion rate" seems a rather subjective term. I take it to mean the rate that might be expected for a reasonably well designed beachfront at Revere. Following the initial readjustment period a rate of less than 10,000yds^3/year should be able to be maintained. Meteorological conditions prevailing during the observation period could however, significantly increase this number. If, for example, ten 100 year storm events occurred within a single decade stability could be essentially precluded. Hopefully if below average conditions prevailed during the next decade a major fraction of these materials would return to the beachface resulting in average loss rates of less than 10,000yds^3/yr.

Question No.7 The problem with such a beach should be apparent from comments provided as part of Question No.5. A top elevation of 9ft NGVD would expose most of the beachface to significant energy during the 100yr event. The reference to the Master Plan is not clear. It appears that the plan called for an elevation along the seawall of 15ft NGVD. Is there some difficulty with the datum?

Question No.8 The answer to this question is unknown at this time. There is every indication that groundwater seepage represents an important factor within the overall stability of Revere Beach particularly within the Reach fronting the MDC Bath-house. The correlation between groundwater flow as measured by Dr. John Swallow for the MDC and areas of narrow beachfront and apparently accelerated erosion is suggestive. Further determination of through-beach flow rates and the probable sources of the waters seems warranted.

Question No. 9 See the above comments related to Question No. 5. Given the required "fairing" to achieve stable contours fill placement at Wonderland (MDC Bath-house area) and North Beaches essentially represents sanding of the entire beach. If phasing was required priority should be given to the southernmost reach (Reach B). It does not appear advisable to sand the northern section prior to completion of the southern section.

Question No. 10 The question of esthetics was discussed in some detail. Depending on the volume of sand required to complete the various phases of resanding it should be possible to obtain sands having the proper textural properties to satisfy dynamic considerations and an acceptable color to satisfy local residents and beach users. It was suggested that contact be made with Childs Engineering Corp. of Medfield,Mass. to review the sand samples and probable source area information obtained as part of the MDC Lynn Beach study. The approach in which a single source of material is used appears preferable to any attempt to develop a two layer structure. If such a structure was to be constructed the esthetically unaccceptable sands would have to remain isolated within the core. Given the dynamic character of Revere Beach this will probably be difficult if not impossible to do. It should be remembered that many of the sands obtained from terrestrial borrow pits will approach the color of beach sand following a suitable weathering period. Tests to determine the extent to which this will occur and yield acceptable colors should be considered. Also it is possible that a marine source area could be used as the source of renourishment sands.

Question No.11 Given the present sedimentation characteristics near the entrance to the Saugus/Pines River system it appears unlikely that significant quantities of sands placed along Revere Beach will be transported into the areas fronting Lynn Harbor. Materials reaching the distal end of the beach will tend to be carried either northwest into the river or offshore into Broad Sound. Some fractions of these materials may accumulate within the navigational channel. To determine the quantitative extent of this deposition additional information detailing currents and the extent of wave-current interaction in this area is required. From the response of the area following previous resanding activities significant infilling due to materials transported from the beach appears unlikely.

Question No.12 This was the defined limits of the MDC project. See Gale survey maps included in the Master Plan.

Question No.13 Contact the MDC for permission to reproduce the Beachfront portion of the Master Plan.

Question No.14 There were many other questions discussed including sources of funding, ways to expedite the project and the need for information dissemination at an early stage so as to involve the public as much as possible and to minimize later "surprises".

Question No.15 There is every indication that restoration of the beachfront along Revere Beach represents a viable means to increase both recreational utility and flood protection for the backshore. As such there are no grounds to justify "screening out" at this time. All of the options discussed appear to merit further investigation.

Question No.16 Beachfront survey and bathymetric data indicate that the February 1978 storm served to move large volumes of sediment within the shallows fronting Revere Beach. Along the beachfront itself relatively small volumes of sediment were displaced by the storm. The primary reasons for this transport pattern appeared to be the sheltering provided by Nahant and the extent of the shallows fronting the Beach. In the absence of renourishment similar storm conditions are expected to produce similar results. Following renourishment however, beachfront displacements could be significantly different. This would be particularly true if the storm occurred during the immediate post-project period when the placed sands are highly susceptible to displacement. The volumes involved and their ultimate destination will depend on the character of the material and the design contours of the beach. Following the readjustment period, the impact of a major storm event on the placed sands will vary as a function of the same parameters (grain size and selected contours). Calculations could be developed to estimate the volumes displaced under a variety of conditions. Without doubt however, the volumes of beachfront materials displaced after renourishment and readjustment will be higher than those displaced at present. It appears to be simply the result of having more material to move around. Properly designed however, this displacement will not result in significant net losses of material from the beachfront system.

APPENDIX A

REVERE BEACH BACKSHORE STUDY
QUESTIONS FOR WORKSHOP WITH DR. BOHLEN
APRIL 4, 1983

1. Is additional effort needed to define the deep water wave and to develop wave refraction for these feasibility studies; or wait for the advanced engineering and design stage? Ref: Master Plan Tech. Rpt. 12/78, Oceanography and Beach, W.F. Bohlen, pgs. 190+205.

2. Is it possible for the 1978 et.al. stillwater to be higher at Revere than Boston? Ref: Master Plan EIS Appendix J-2.

3. Is it reasonable to assume existing conditions (beach profiles) will not significantly erode for Reach A (Crescent Beach) and Reach C (Oak Island Street) over the next a) 50 and b) 100 years, recognizing Reaches A and C have gradually built up since 1900? Ref: Handout and Dr. Bohlen's Report pg. 205

4. Although the runup analysis shows no overtopping should sections A and C beach width or elevation be increased or additional measures taken to provide protection for either the 100 year, 500 year or SPN flood events-design options? (Stillwater levels: 10.3, 11.2, 13.0 feet NGVD, respectively.) Ref: Handout

5. What are acceptable beach designs in Reaches B and D (Wonderland and North Beach) to prevent reaching critical overtopping condition over the next 50-100 years. Consider designs with 100' wide berm and top of beach at either design SWL/SWL + 1'/SWL + 2', slope 1:15? Compare to incremental costs and benefit versus better materials (i.e. bankrun) to justify lower slope. Ref: Handout

6. What is a reasonable maintenance or erosion rate for A and C and B and D if coarser material is placed. (Historically: 3-4,000 cy/yr average/ 22,000 c.y. maximum in Reach B (1904-1910) may or may not be representative.) Ref: Bohlen pgs 188, 212, 215.

7. Any problem with a recreation only beach design with top elevation at 9.0 feet NGVD, 100' wide berm to 1:15 slope? (Reach B: 170,000 cy @ $1.5 M; Reaches A-D: 330,000 cy @ $3.2 M) Ref: Bohlen, pg 213, El. 10 @ 1:20, 1:100.

8. How critical is the ground water seepage problem to beach stability/ erosion in Reach B? What should be done for further evaluation? Ref: Dr. Bohlen pg. 209, 210.

9. Can the two eroded areas at Wonderland Beach and North Beach be built separately from entire beach? Ref: Bohlen, pg. 223.

10. Would a two layer beach design be acceptable and how best to do it, to achieve an acceptable top layer? (i.e. Base Coarse yellow/Surface coarse white et.al.)

11. What problems or analyses are needed to determine impacts of deposition of new sand in navigation channels, or large amounts reaching Lynn Harbor's shellfish beds, and wintering areas for black ducks? Ref: Dr. Bohlen, pg. 206.

12. The Master Plan recreation beach is taken to Oak Island Street. Why and how is the area computed? Ref: Dr. Bohlen, pg. 211.

13. Permission to reproduce Dr. Bohlen's report?

14. Additional questions on Dr. Bohlen's Ocean/Beach Report or other issues.

15. Can we decide at this time whether or not beach restoration options should be screened out as alternatives for flood protection, or should the options be investigated further?

16. The Blizzard of '78 show ed no significant erosion, can this be typical of future events with or without beach restoration? Ref: Bohlen, pg. 211.

PRELIMINARY

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE 1/2

SUBJECT: REVERE BEACH BACKSHORE
COMPUTATION: PLAN FORMULATION REACHES A + C
COMPUTED BY: RGH   CHECKED BY: ____   DATE: 29 MAR 83

SECTION TYPICAL TO:
REACH "A" CRESCENT BEACH
REACH "C" OAK ISLAND ST.

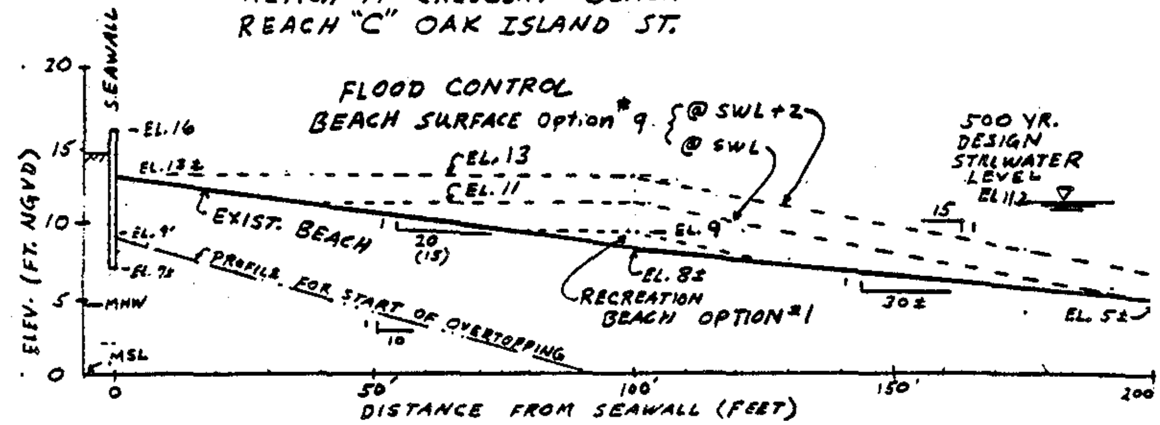


TABLE #1 BEACH RESTORATION -- 500 YR. DESIGN OPTIONS

Incremental Cost + Quan. FOR REACHES A + C	SWL @ 11.0	SWL+1' @ EL. 12	SWL+2' @ EL 13
QUANTITY 1)	130,000 CY	190,000 CY	240,000 CY
COST 2)	$1.5 Million	$2.5 M	$3.4 M

1) Excludes feathering from B+D   2) Includes 25% Contg. + 25% EDSA

TABLE #2 RUNUP ON FLOOD CONTROL BEACH

EVENT SWL:	13.0	11.2	10.3	
TOP BEACH EL. 12-15 @ 1:15 slope:	El. 15.8	El. 13.9	El. 12.9	Top of Runup

TABLE #3 RUNUP ON EXISTING BEACH

		SEC. A1	SEC. C3
Top /Beach + Slope:		EL. 14.5 @ 1:20	EL. 12 @ 1:15
EVENT	SWL EL.	TOP RUN UP EL.	TOP RUNUP EL.
SPN	13.0	15.0	15.5
500 YR.	11.2	13.2	13.5
100 YR.	10.3	12.3	12.5

TABLE #4 BEACH HISTORY

SECTION A1 (R14)

Feet From Seawall: / YEAR	BEACH ELEV. (FT.NGVD) 100'	200'	300'	400'
1980	9.9	5.9	2.9	0.9
1945	8.9	2.9	0.9	-1.1
1900	4.9	-1.6	-2.6	-2.6

SECTION C3 (R3)

Feet: / YEAR	BEACH ELEV. (FT.NGVD) 100'	200'	300'	400'
1980	6.9	4.9	2.9	0.4
1945	4.9	1.9	0.4	-1.1
1900	4.9	2.4	0.4	-1.6

PRELIMINARY

NED FORM 223
27 Sept 49

A-4
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE 2/2

SUBJECT: REVERE BEACH BACKSHORE STUDY
COMPUTATION: PLAN FORMULATION REACHES B + D
COMPUTED BY: RGH CHECKED BY: DATE: 29 MAR 83

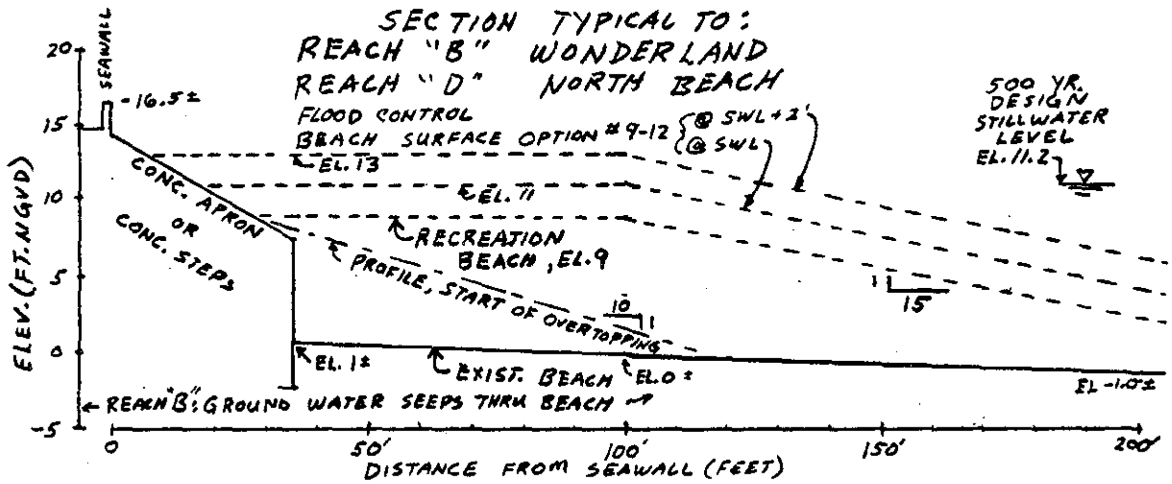


TABLE #1 BEACH RESTORATION -- 500 YR. DESIGN OPTIONS

Option	CONSTRUC. COST FOR REACH	TOP @ SWL EL 11	SWL + 1' EL 12	SWL + 2' EL 13
9	A, B, C + D	$ 6.8 M	$ 8.8 M	$ 11.0 M
10	B + D	$ 5.3	$ 6.3	$ 7.6
11	B only	$ 2.8	$ 3.6	$ 4.2
12	D only	$ 2.0	$ 2.1	$ 2.6

TABLE #2 RUNUP ON FLOOD CONTROL BEACH

EVENT SWL:	EL. 13.0	11.2	10.3	
TOP BEACH EL. 12-15 @ 1:15 slope:	EL. 15.8	EL. 13.9	EL. 12.9	TOP OF RUNUP

TABLE #3 RUNUP ON EXISTING BEACH / WALL

		SEC. B3 (Apron)	SEC D1 (Steps)
TOP / BEACH + SLOPE:		EL. 1.0 @ 1:50	EL. 1.0 @ 1:15±
EVENT	SWL EL	TOP RUNUP, EL.	TOP RUNUP, EL.
SPN	13.0	>20, <36	23.8
500 YR.	11.2	>18, <31	21.5
100 YR.	10.3	>17, <28	18.4

TABLE #4 BEACH HISTORY

SECTION B3 (R6)

Feet from SEAWALL: BEACH ELEVATION (FT. NGVD)

YEAR	100'	200'	300'	400'
1980	-0.1	-1.6	-2.6	-4.6
1945	0.4	-1.6	-2.6	-4.6
1900	3.4	2.4	-2.1	-4.6

SECTION D2 (R2)

BEACH ELEV.

	100'	200'	300'	400'
1980	-0.1	-2.6	-3.1	-4.1
1945	0.9	-2.1	-3.1	-3.1
1904	3.4	-1.6	-2.1	-3.6
1900	7.9	0.4	-2.1	-3.1

ADDENDUM 4

EXISTING AND MODIFIED
FLOOD STAGE VS. FREQUENCY
FOR
SPN REGIONAL PLAN

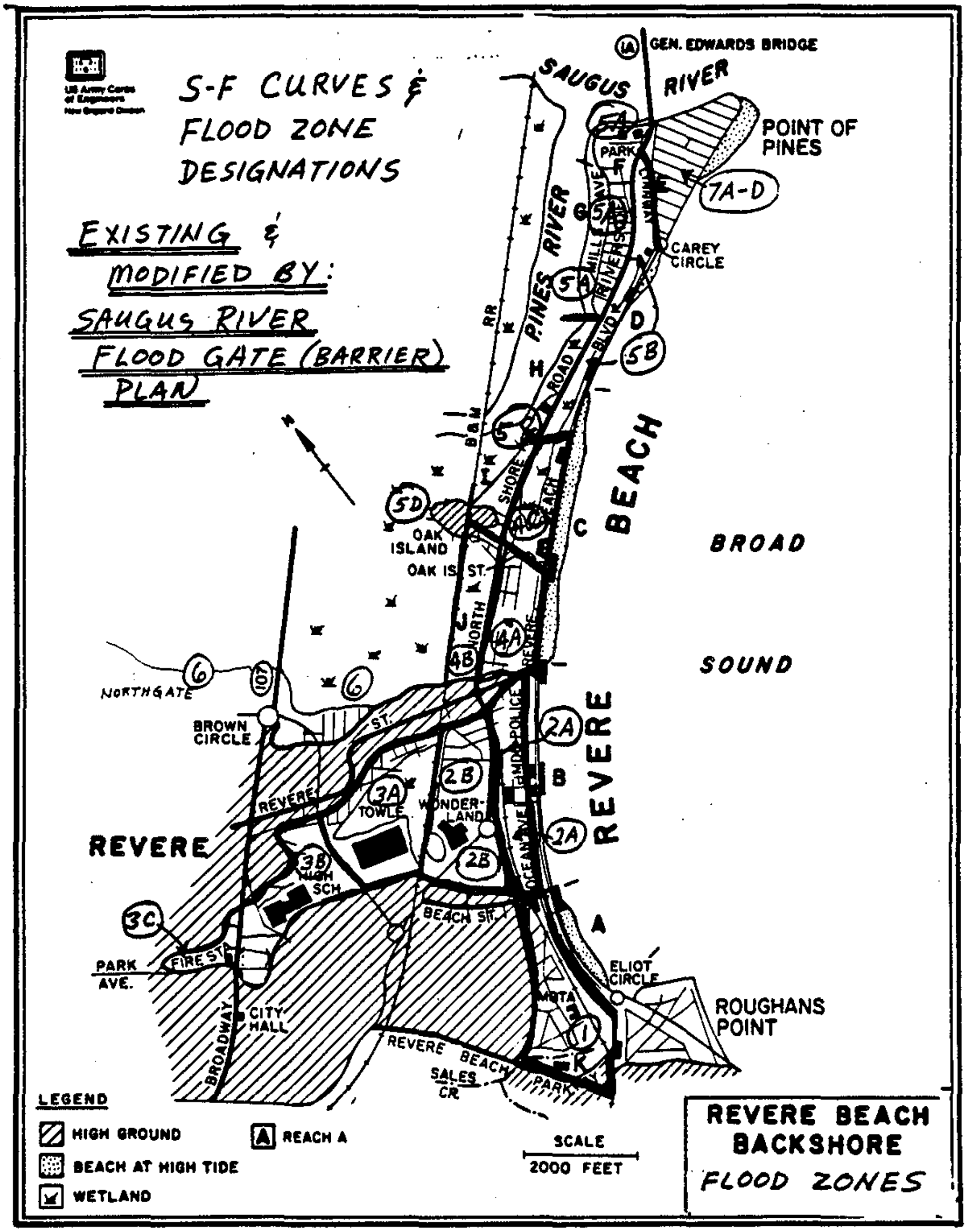

US Army Corps of Engineers
New England Division
S-F CURVES & FLOOD ZONE DESIGNATIONS
EXISTING & MODIFIED BY: SAUGUS RIVER FLOOD GATE (BARRIER) PLAN
GEN. EDWARDS BRIDGE
SAUGUS RIVER
POINT OF PINES
PINES RIVER
CAREY CIRCLE
BEACH
BROAD
SOUND
REVERE
OAK ISLAND
OAK IS. ST.
NORTHGATE
BROWN CIRCLE
TOWLE
WONDERLAND
HIGH SCH
BEACH ST.
PARK AVE.
FIRE STA
CITY HALL
BROADWAY
REVERE BEACH PARK
SALES CR.
ELIOT CIRCLE
ROUGHANS POINT
LEGEND
HIGH GROUND
BEACH AT HIGH TIDE
WETLAND
REACH A
SCALE
2000 FEET
REVERE BEACH BACKSHORE
FLOOD ZONES

FIGURE SF-1

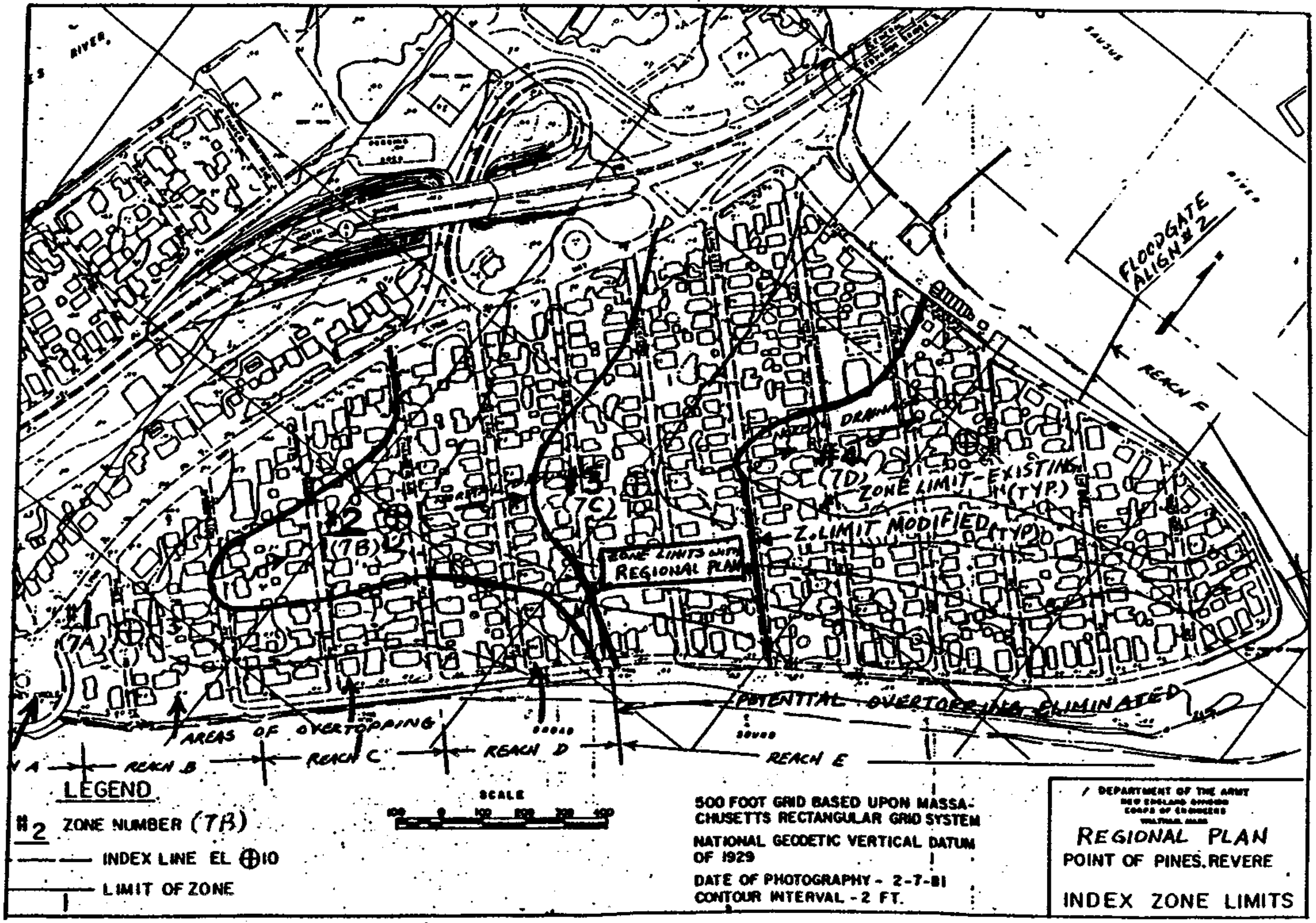

RIVER
SAUGUS
RIVER
FLOODGATE ALIGN #2
REACH F
DRAINAGE
#4
(7D)
ZONE LIMIT-EXISTING (TYP.)
Z. LIMIT MODIFIED (TYP.)
#3
(7C)
ZONE LIMITS WITH REGIONAL PLAN
#2
(7B)
#1
(7A)
AREAS OF OVERTOPPING
POTENTIAL OVERTOPPING ELIMINATED
REACH A
REACH B
REACH C
REACH D
REACH E
LEGEND
#2 ZONE NUMBER (7B)
INDEX LINE EL ⊕10
LIMIT OF ZONE
SCALE
500 FOOT GRID BASED UPON MASSACHUSETTS RECTANGULAR GRID SYSTEM
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DATE OF PHOTOGRAPHY - 2-7-81
CONTOUR INTERVAL - 2 FT.
DEPARTMENT OF THE ARMY
REGIONAL PLAN
POINT OF PINES, REVERE
INDEX ZONE LIMITS

FIGURE SF-2

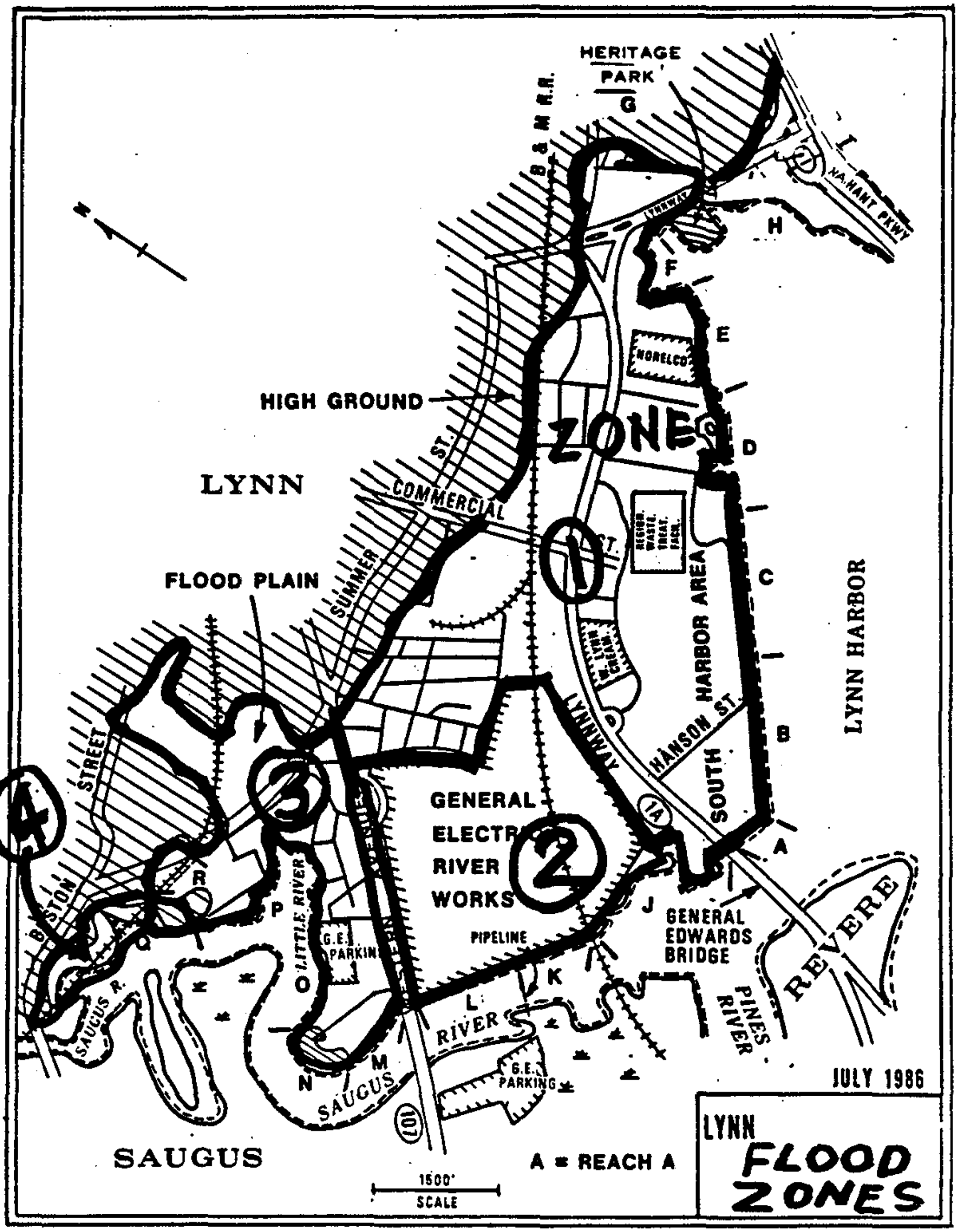
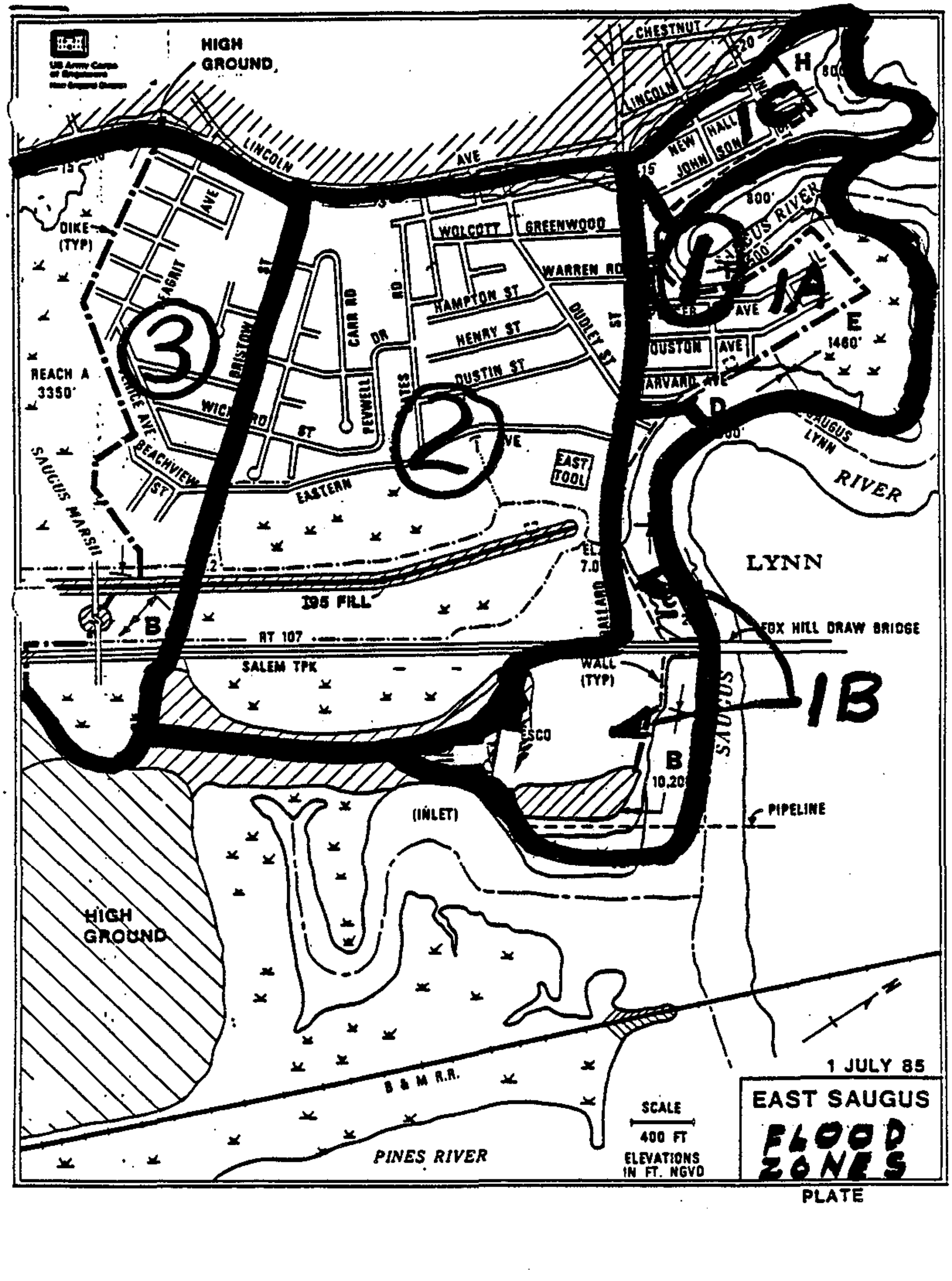
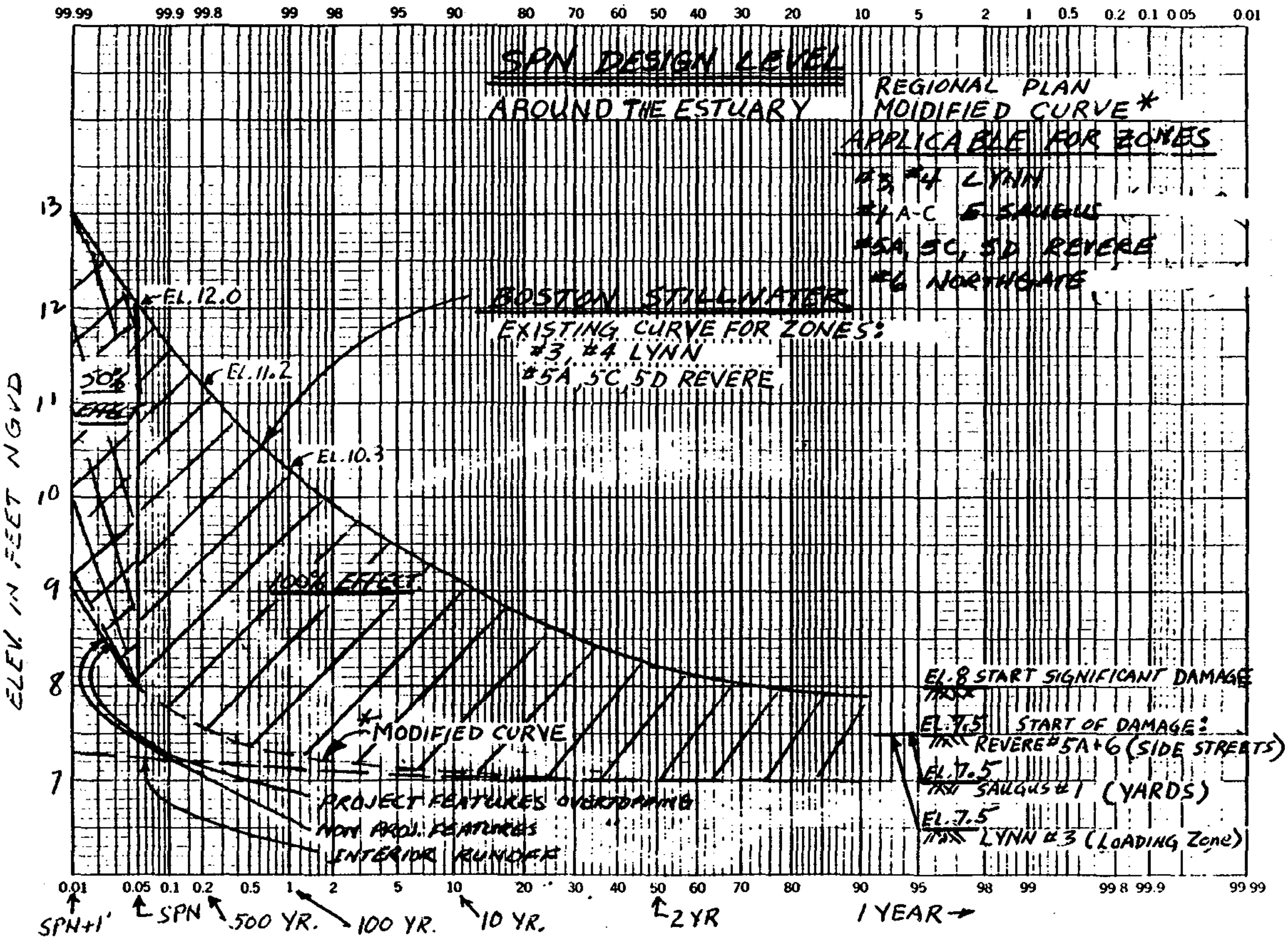

HERITAGE
PARK
G
B & M R.R.
NAHANT PKWY
LYNNWAY
H
F
E
NORELCO
HIGH GROUND
ZONE
D
LYNN
COMMERCIAL
ST.
REGION. WASTE TREAT. FACIL.
C
FLOOD PLAIN
SUMMER
HARBOR AREA
LYNN HARBOR
LYNNWAY
HANSON ST.
B
SOUTH
1A
STREET
GENERAL
ELECTR
RIVER
WORKS
A
BOSTON
R
P
LITTLE RIVER
PIPELINE
J
GENERAL
EDWARDS
BRIDGE
REVERE
Q
G.E.
PARKIN
K
SAUGUS R.
O
L
RIVER
PINES
RIVER
N
M
SAUGUS
G.E.
PARKING
JULY 1986
107
LYNN
FLOOD
ZONES
SAUGUS
1500'
SCALE
A = REACH A

FIGURE SF-3



HIGH GROUND
US Army Corps of Engineers
LINCOLN AVE
CHESTNUT
LINCOLN
NEW JOHN
HALL SON
H
800'
1C
SAUGUS RIVER
DIKE (TYP)
WOLCOTT
GREENWOOD
WARREN RD
HAMPTON ST
HENRY ST
DUSTIN ST
DUDLEY ST
CARR RD
1
1A
E
1460'
HOUSTON AVE
HARVARD AVE
D
3
REACH A 3350'
BRISTOW ST
SEAGRIT
WICKFORD RD
BEACHVIEW ST
SAUGUS MARSH
2
EASTERN AVE
EAST TOOL
SAUGUS LYNN RIVER
LYNN
195 FILL
EL 7.0
BALLARD ST
B
RT 107
SALEM TPK
FOX HILL DRAW BRIDGE
WALL (TYP)
1B
SAUGUS
B 10.20
PIPELINE
(INLET)
HIGH GROUND
B & M R.R.
PINES RIVER
SCALE 400 FT
ELEVATIONS IN FT. NGVD
1 JULY 85
EAST SAUGUS
FLOOD ZONES
PLATE

FIGURE SF-4



SPN DESIGN LEVEL
AROUND THE ESTUARY
REGIONAL PLAN
MODIFIED CURVE*
APPLICABLE FOR ZONES
#3, #4 LYNN
#1A-C SAUGUS
#5A, 5C, 5D REVERE
#6 NORTHGATE
BOSTON STILLWATER
EXISTING CURVE FOR ZONES:
#3, #4 LYNN
#5A, 5C, 5D REVERE
EL. 12.0
EL. 11.2
EL. 10.3
50% EFFECT
100% EFFECT
*MODIFIED CURVE
PROJECT FEATURES OVERTOPPING
NON PROJ. FEATURES
INTERIOR RUNOFF
EL. 8 START SIGNIFICANT DAMAGE
EL. 7.5 START OF DAMAGE: REVERE #5A+6 (SIDE STREETS)
EL. 7.5 SAUGUS #1 (YARDS)
EL. 7.5 LYNN #3 (LOADING Zone)
ELEV. IN FEET NGVD
SPN+1'
SPN
500 YR.
100 YR.
10 YR.
2 YR
1 YEAR

FIGURE SF-5

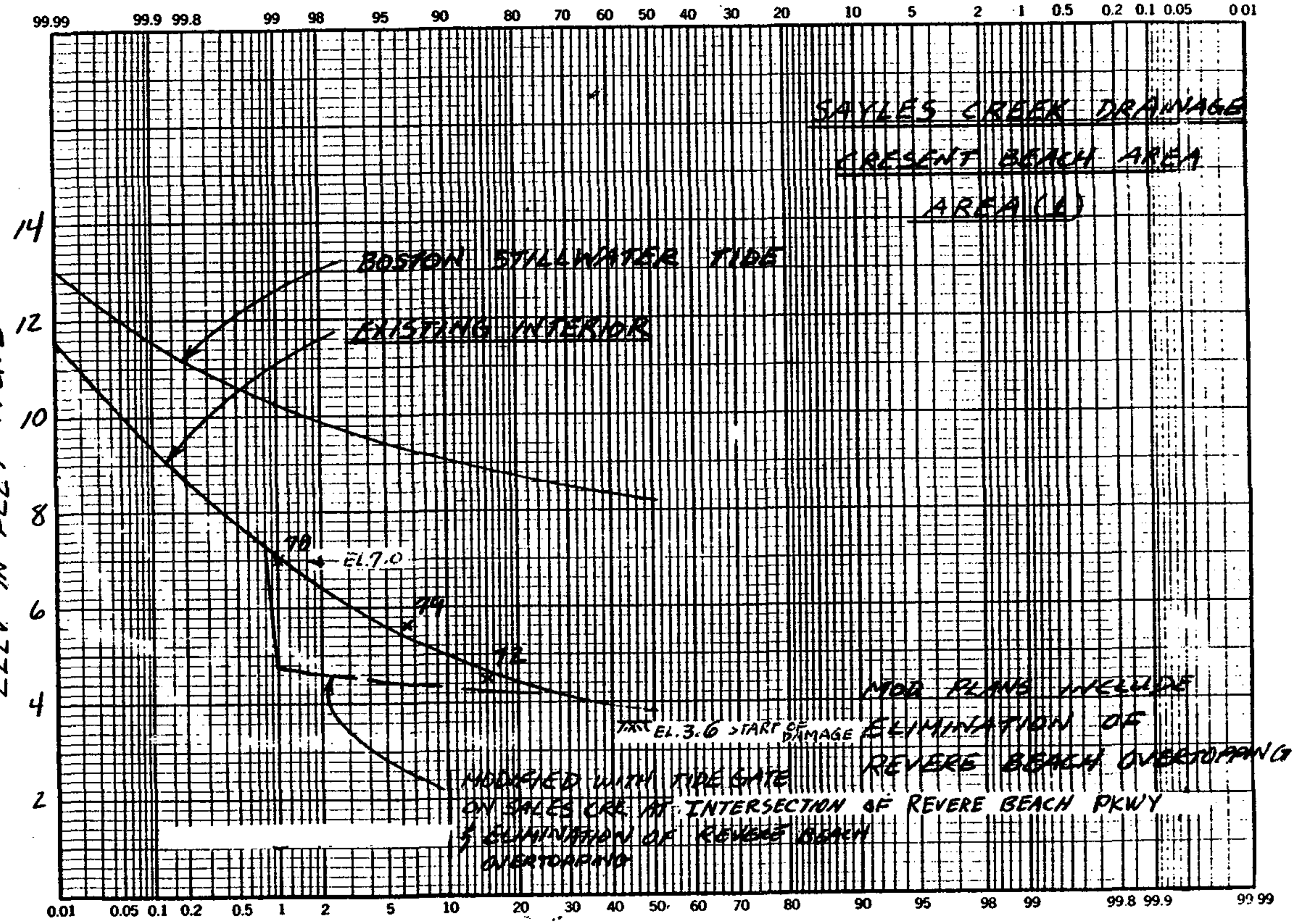

SAYLES CREEK DRAINAGE
CRESENT BEACH AREA
AREA (1)
BOSTON STILLWATER TIDE
EXISTING INTERIOR
ELEV. IN FEET NGVD
EL.7.0
EL.3.6 START OF DAMAGE
MOD PLANS INCLUDE ELIMINATION OF REVERE BEACH OVERTOPPING
MODIFIED WITH TIDE GATE ON SALES CRK AT INTERSECTION OF REVERE BEACH PKWY & ELIMINATION OF REVERE BEACH OVERTOPPING

FIGURE SF-6

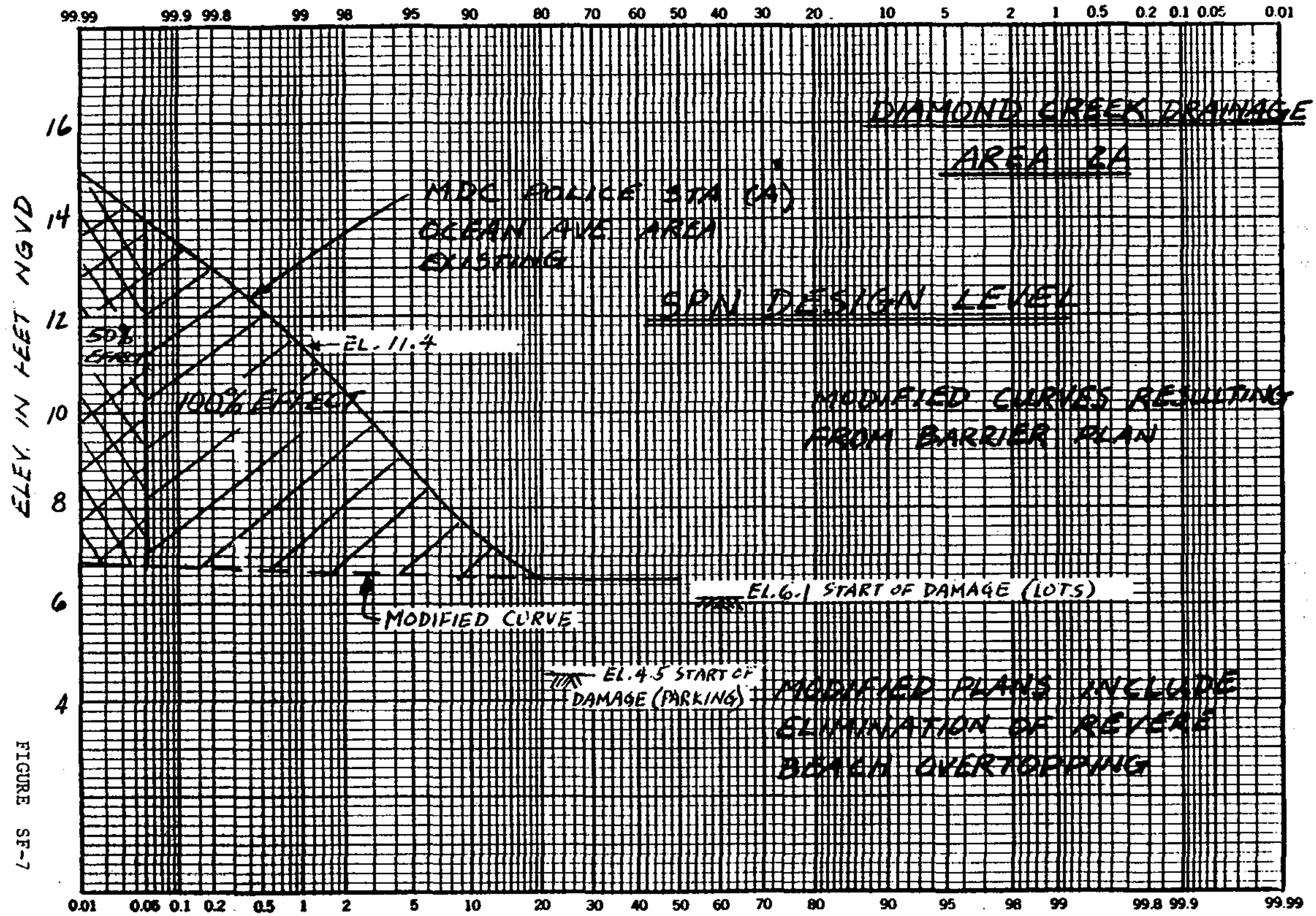

DIAMOND CREEK DRAINAGE
AREA 2A
MDC POLICE STA (A)
OCEAN AVE AREA
EXISTING
SPN DESIGN LEVEL
EL. 11.4
50% EFFECT
100% EFFECT
MODIFIED CURVES RESULTING FROM BARRIER PLAN
MODIFIED CURVE
EL. 6.1 START OF DAMAGE (LOTS)
EL. 4.5 START OF DAMAGE (PARKING)
MODIFIED PLANS INCLUDE ELIMINATION OF REVERE BEACH OVERTOPPING
ELEV. IN FEET NGVD
16
14
12
10
8
6
4
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

FIGURE SF-7

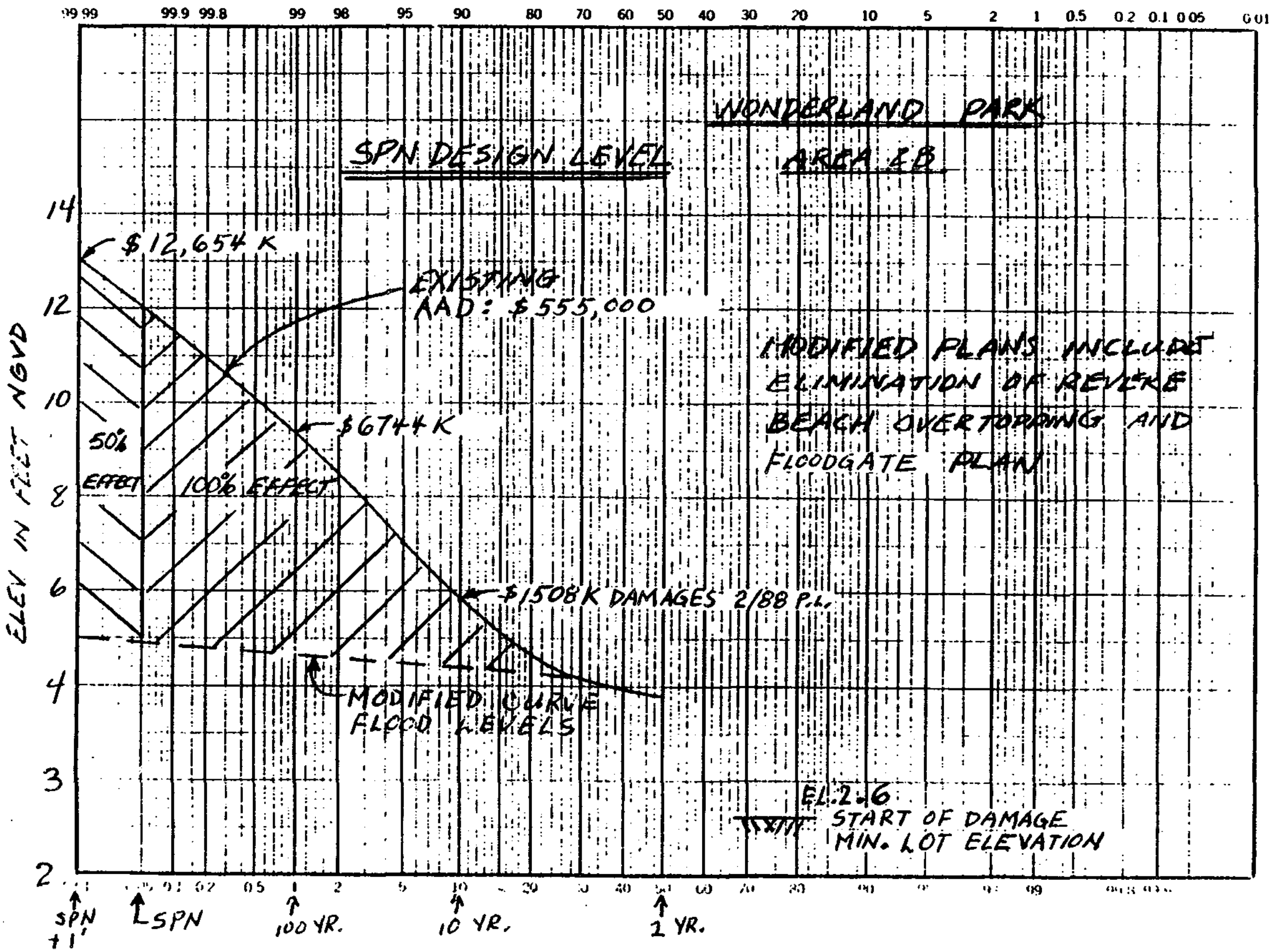

WONDERLAND PARK
AREA 8B
SPN DESIGN LEVEL
$12,654 K
EXISTING
AAD: $555,000
MODIFIED PLANS INCLUDE
ELIMINATION OF REVERE
BEACH OVERTOPPING AND
FLOODGATE PLAN
$6744 K
50% EFFECT
100% EFFECT
$1508 K DAMAGES 2/88 P.L.
MODIFIED CURVE
FLOOD LEVELS
EL.2.6
START OF DAMAGE
MIN. LOT ELEVATION
ELEV IN FEET NGVD
14
12
10
8
6
4
3
2
SPN +1'
SPN
100 YR.
10 YR.
1 YR.

FIGURE SF-8

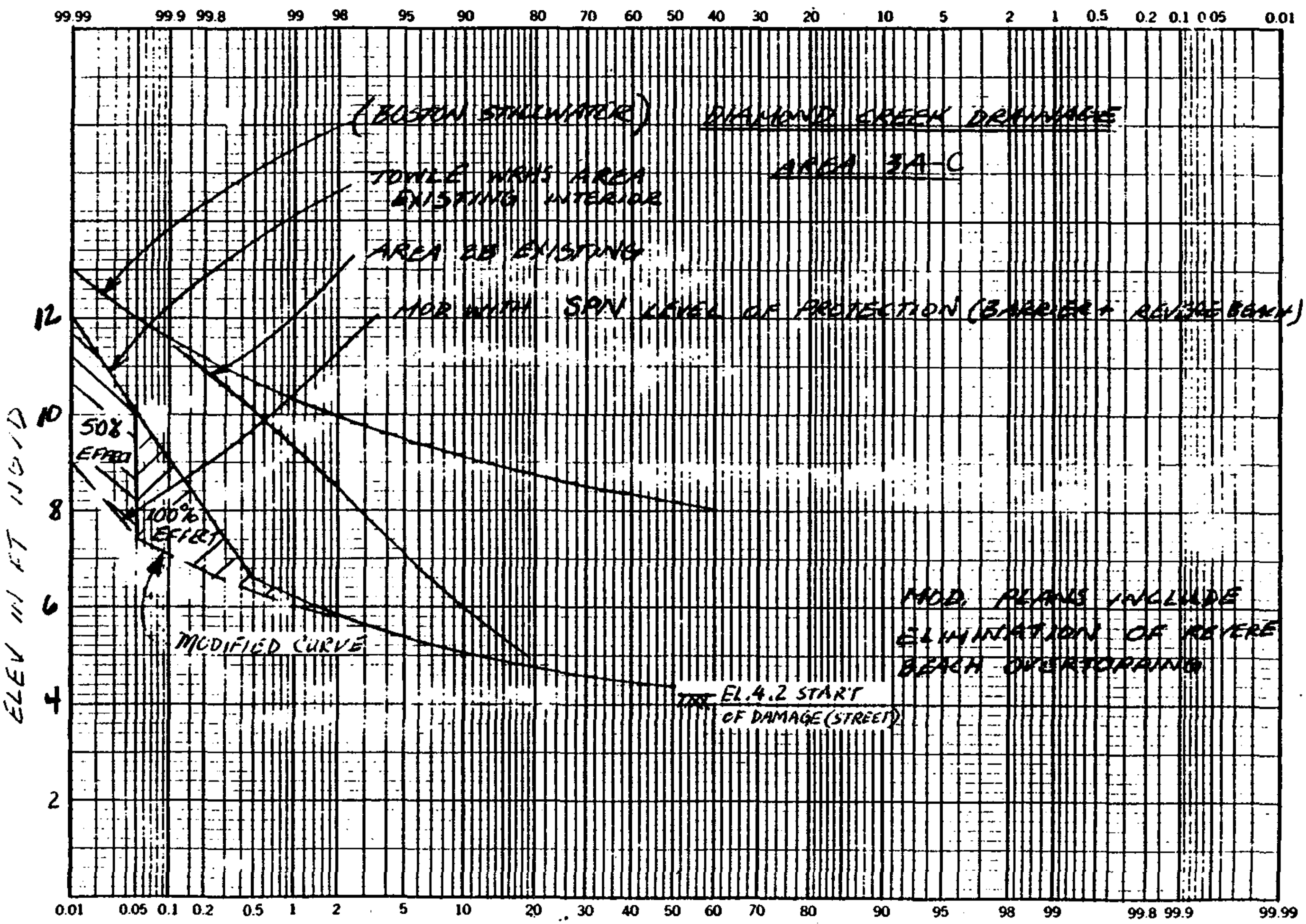
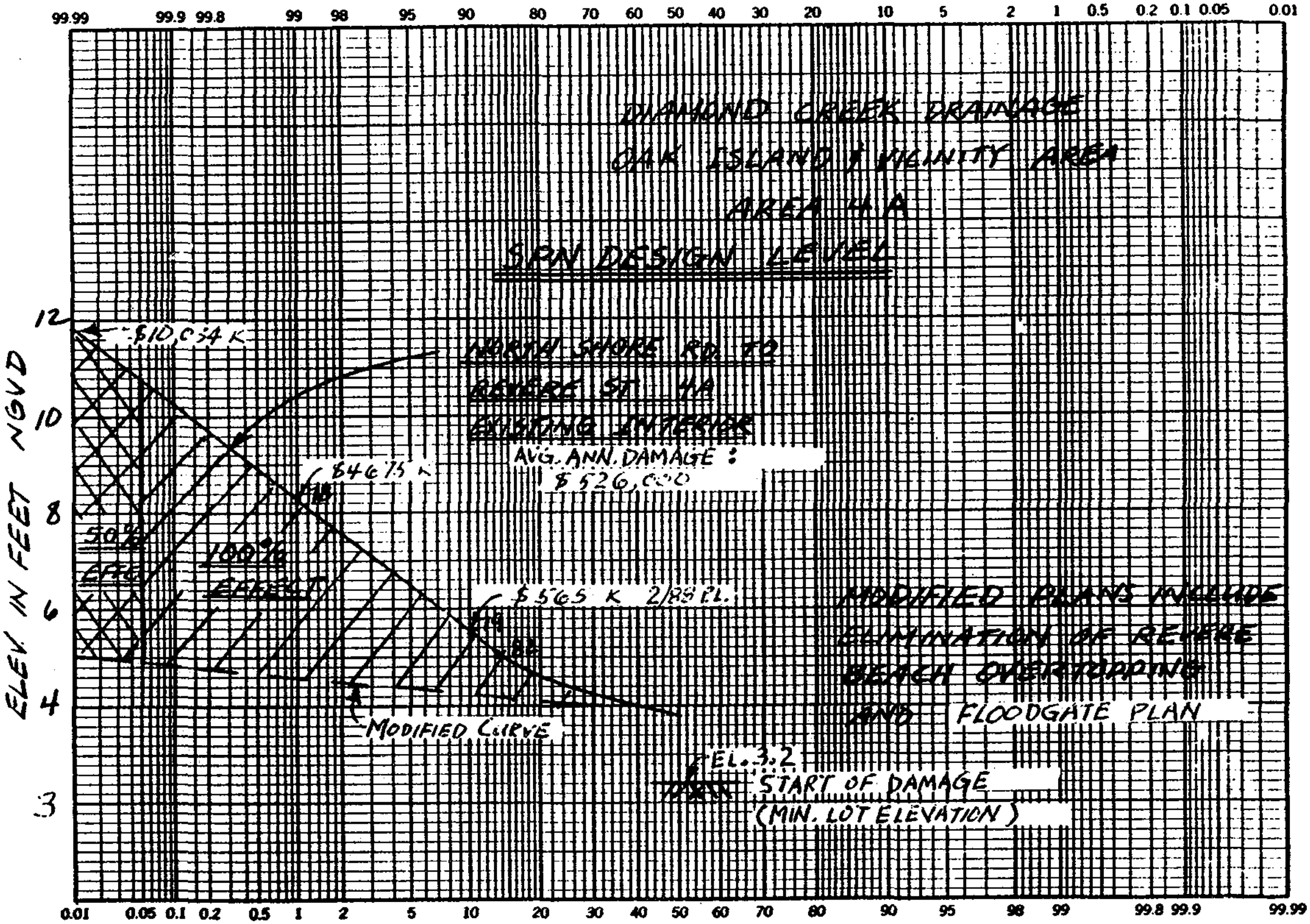

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
(BOSTON STILLWATER)
DIAMOND CREEK DRAINAGE
AREA 3A-C
AREA 2B EXISTING
12
10
8
6
4
2
50%
100% EFFECT
MODIFIED CURVE
MOD. PLANS INCLUDE ELIMINATION OF REVERE BEACH OVERTOPPING
EL. 4.2 START OF DAMAGE (STREET)
ELEV IN FT NGVD
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

FIGURE SF-9



99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
DIAMOND CREEK DRAINAGE
OAK ISLAND & VICINITY AREA
AREA 4A
SPN DESIGN LEVEL
ELEV. IN FEET NGVD
12
10
8
6
4
3
NORTH SHORE RD. TO
ST. 4A
EXISTING INTERIOR
AVG. ANN. DAMAGE:
$526,000
50% EFF.
100% EFFECT
$565 K 2/88 PL.
MODIFIED PLANS INCLUDE
ELIMINATION OF REVERE
BEACH OVERTOPPING
AND FLOODGATE PLAN
MODIFIED CURVE
EL. 3.2
START OF DAMAGE
(MIN. LOT ELEVATION)
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

FIGURE SF-10

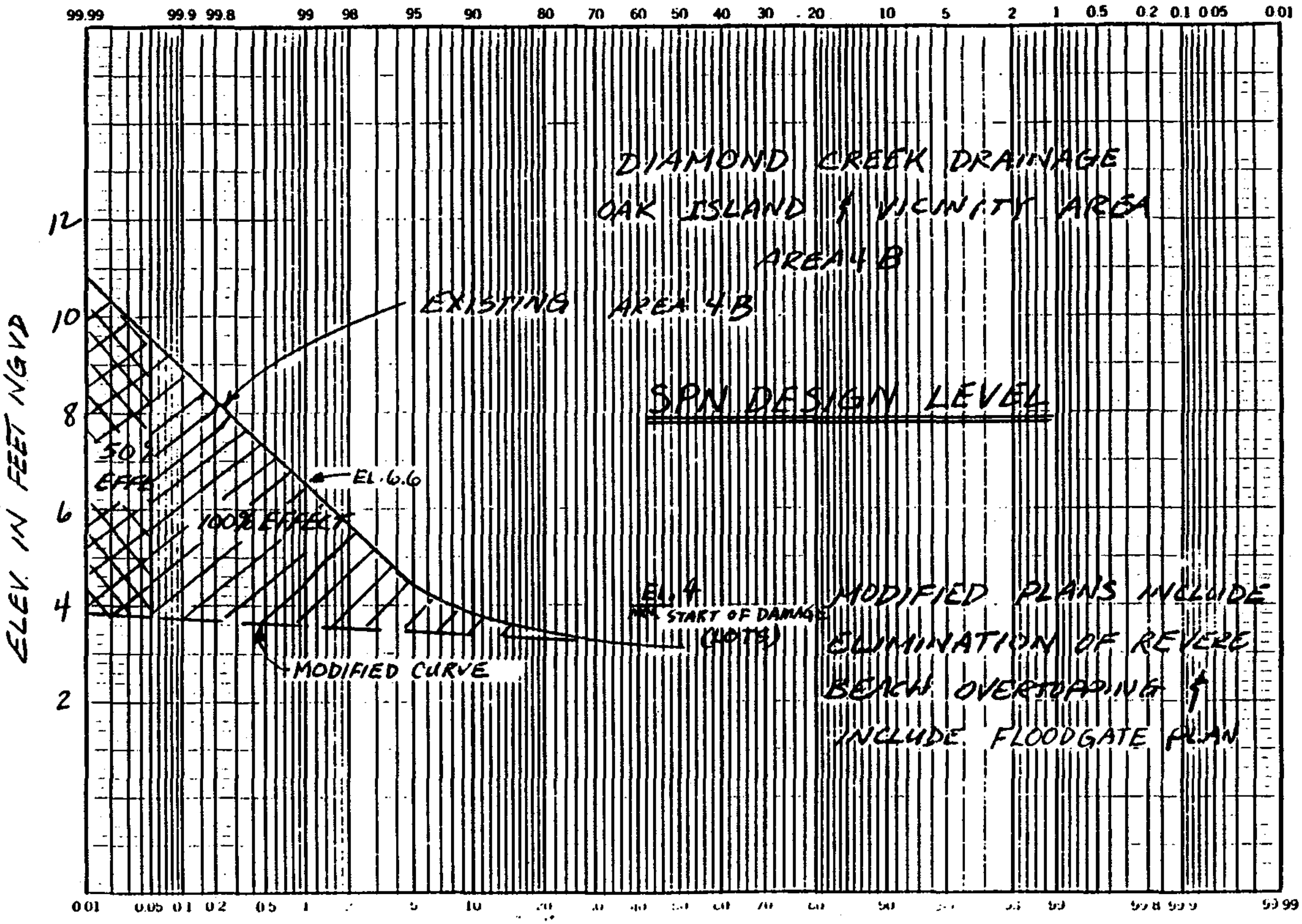

DIAMOND CREEK DRAINAGE
OAK ISLAND & VICINITY AREA
AREA 4 B
EXISTING AREA 4B
SPN DESIGN LEVEL
50% EFFECT
100% EFFECT
EL. 6.6
EL. 4
START OF DAMAGE (NOTE)
MODIFIED CURVE
MODIFIED PLANS INCLUDE ELIMINATION OF REVERE BEACH OVERTOPPING & INCLUDE FLOODGATE PLAN
ELEV. IN FEET NGVD
2
4
6
8
10
12
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
5
10
99.99

FIGURE SF-11

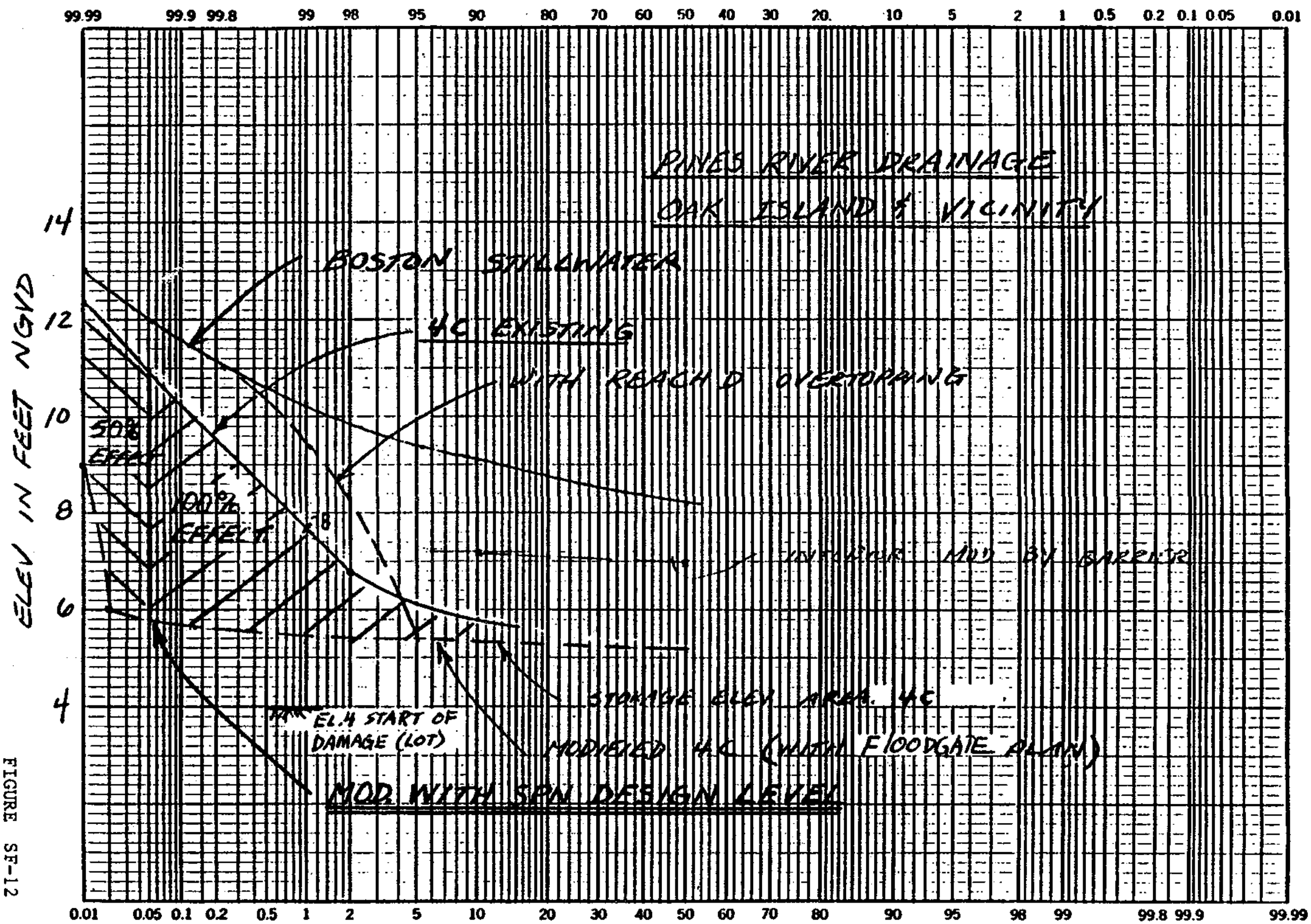

PINES RIVER DRAINAGE
OAK ISLAND & VICINITY
ELEV IN FEET NGVD
BOSTON STILLWATER
4C EXISTING
WITH REACH D OVERTOPPING
50% EFFECT
100% EFFECT
INTERIOR MOD BY BARRIER
STORAGE ELEV AREA 4C
EL.4 START OF DAMAGE (LOT)
MODIFIED 4C (WITH FLOODGATE PLAN)
MOD WITH SPN DESIGN LEVEL

FIGURE SF-12

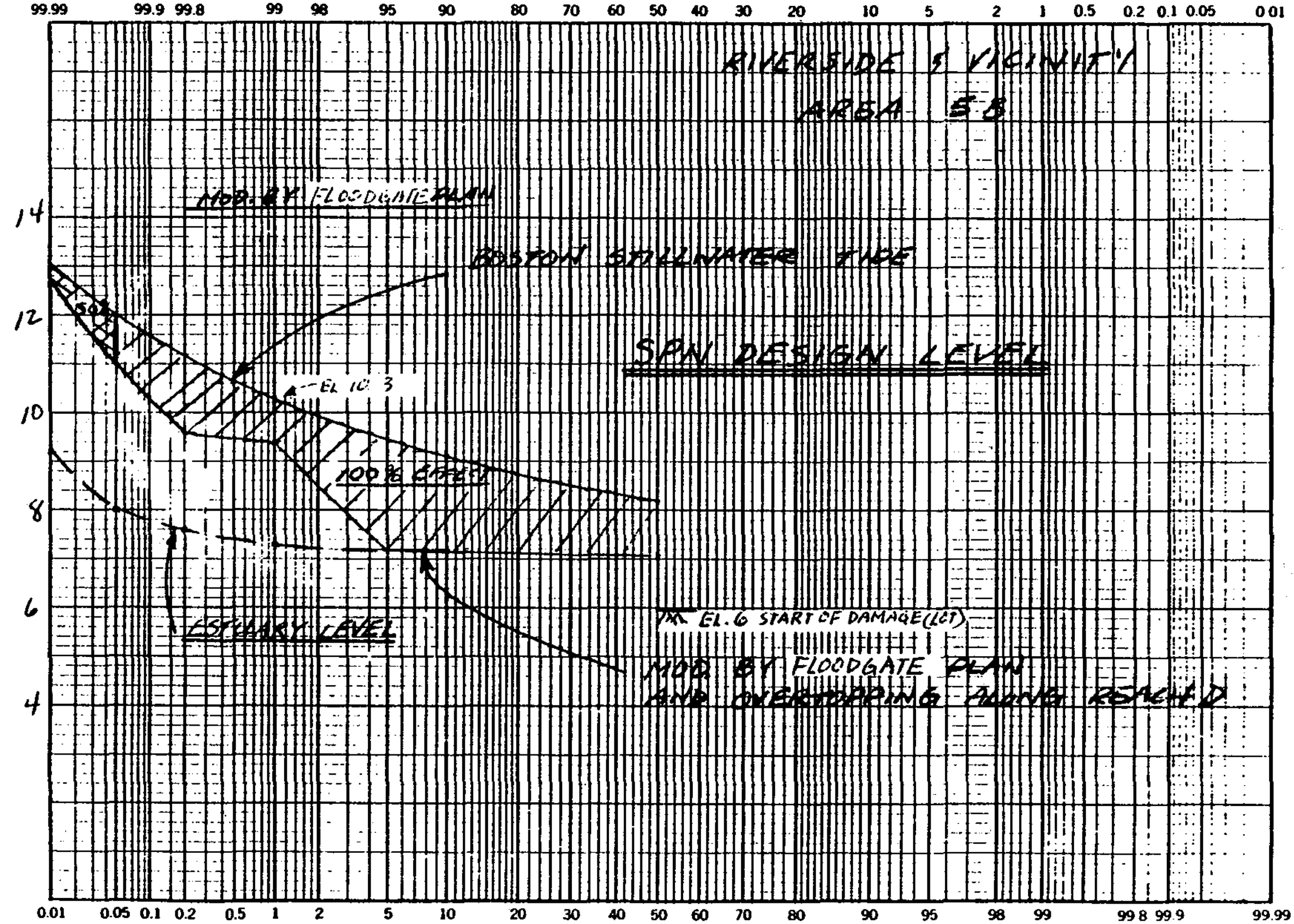

RIVERSIDE & VICINITY
AREA 5B
MOD. BY FLOODGATE PLAN
BOSTON STILLWATER TIDE
SPN DESIGN LEVEL
EL 10.3
50%
100% EFFECT
ESTUARY LEVEL
EL. 6 START OF DAMAGE (LCT)
MOD. BY FLOODGATE PLAN AND OVERTOPPING ALONG REACH D
ELEVATION IN FEET NGVD
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
14 12 10 8 6 4

FIGURE SF-13

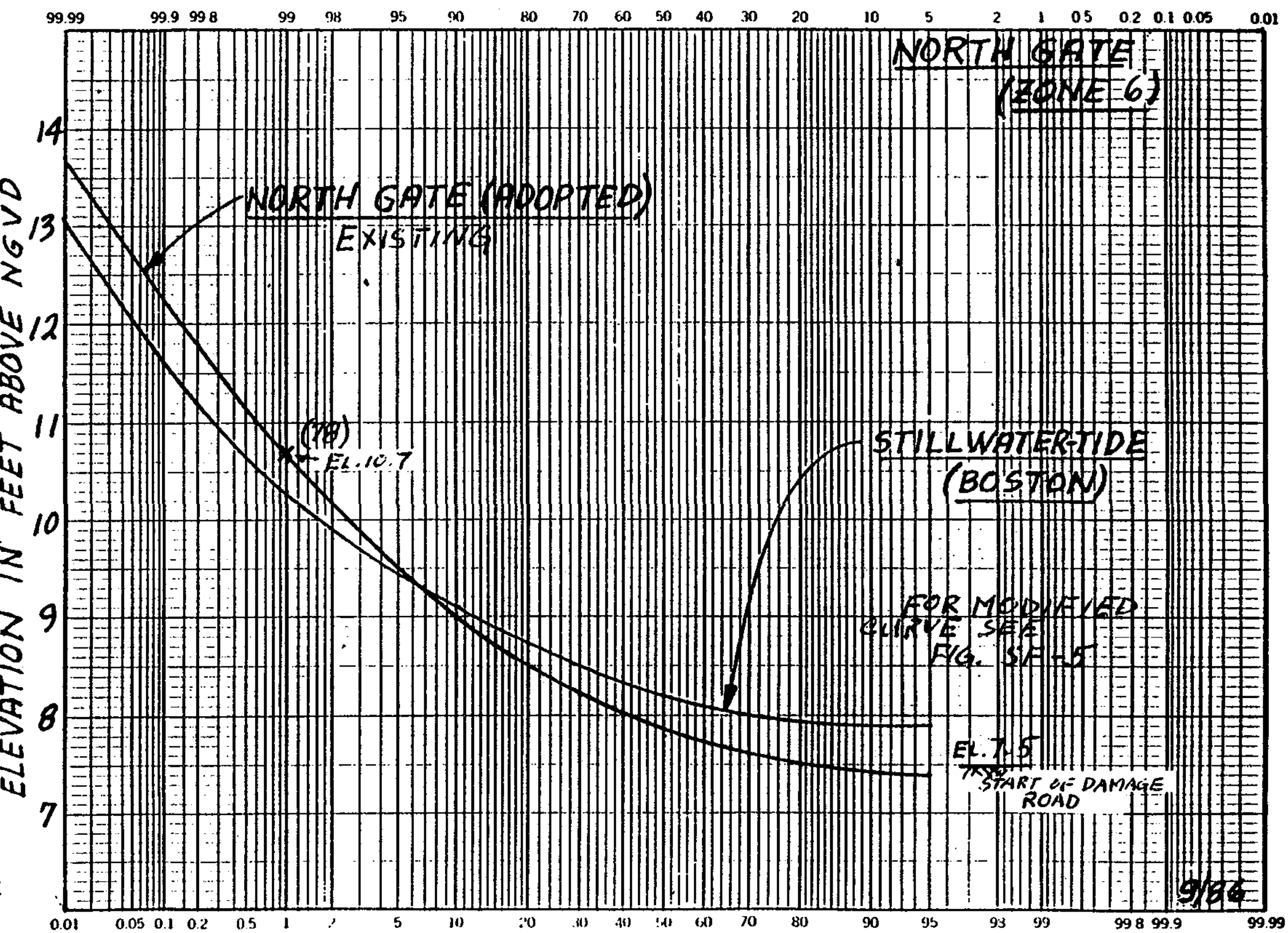
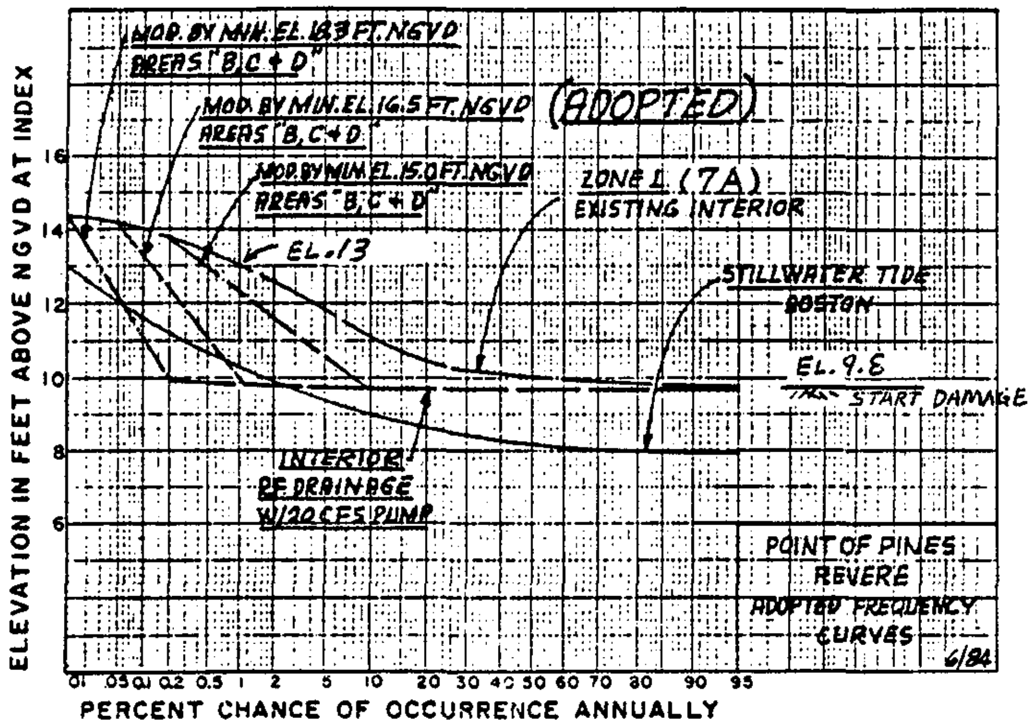
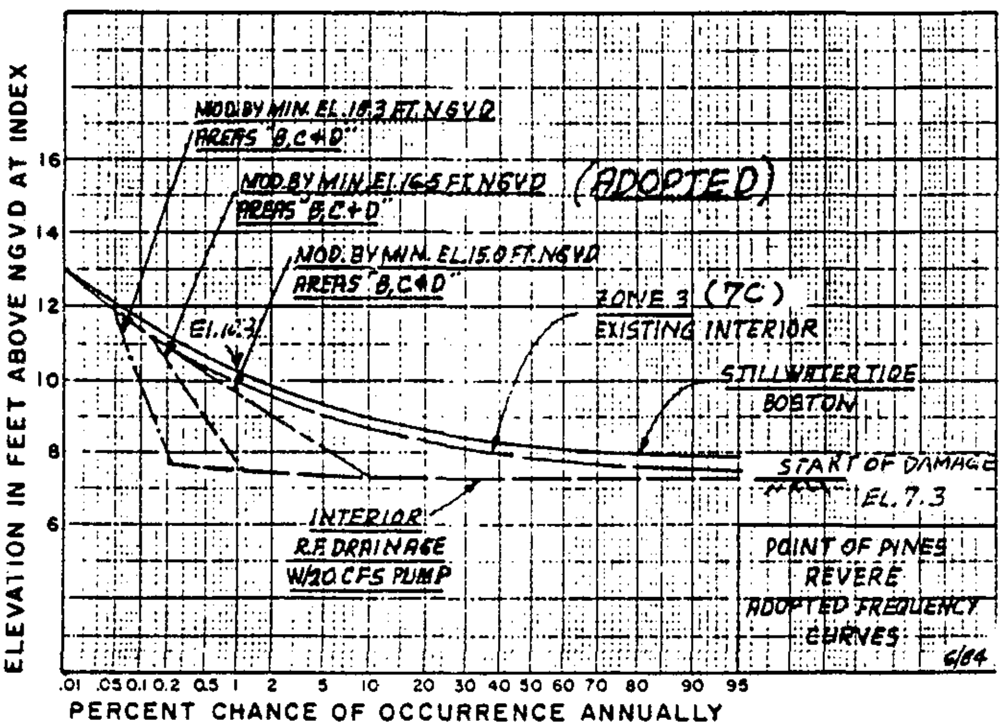

NORTH GATE
(ZONE 6)
NORTH GATE (ADOPTED)
EXISTING
(78)
EL. 10.7
STILLWATER-TIDE
(BOSTON)
FOR MODIFIED
CURVE SEE
FIG. SF-5
EL. 7.5
START OF DAMAGE
ROAD
ELEVATION IN FEET ABOVE NGVD
9/86
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
14
13
12
11
10
9
8
7
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99

FIGURE SF-14

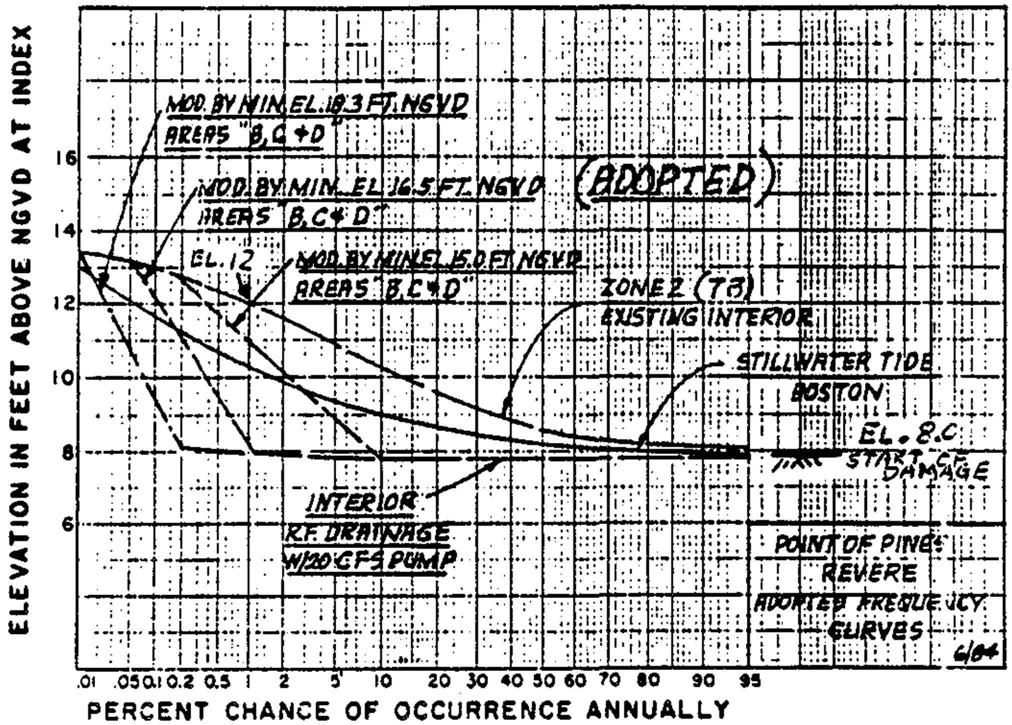


ELEVATION IN FEET ABOVE NGVD AT INDEX
MOD. BY MIN. EL. 18.3 FT. NGVD AREAS "B, C + D"
MOD. BY MIN. EL. 16.5 FT. NGVD AREAS "B, C + D"
(ADOPTED)
MOD. BY MIN. EL. 15.0 FT. NGVD AREAS "B, C + D"
EL. 13
ZONE 1 (7A) EXISTING INTERIOR
STILLWATER TIDE BOSTON
EL. 9.8
START DAMAGE
INTERIOR R.F. DRAINAGE W/20 CFS PUMP
POINT OF PINES REVERE
ADOPTED FREQUENCY CURVES
6/84
PERCENT CHANCE OF OCCURRENCE ANNUALLY



ELEVATION IN FEET ABOVE NGVD AT INDEX
MOD. BY MIN. EL. 18.3 FT. NGVD AREAS "B, C + D"
MOD. BY MIN. EL. 16.5 FT. NGVD AREAS "B, C + D"
(ADOPTED)
MOD. BY MIN. EL. 15.0 FT. NGVD AREAS "B, C + D"
ZONE 3 (7C) EXISTING INTERIOR
STILLWATER TIDE BOSTON
START OF DAMAGE
EL. 7.3
INTERIOR R.F. DRAINAGE W/20 CFS PUMP
POINT OF PINES REVERE
ADOPTED FREQUENCY CURVES
6/84
PERCENT CHANCE OF OCCURRENCE ANNUALLY

FIGURE SF-15


ELEVATION IN FEET ABOVE NGVD AT INDEX
MOD. BY MIN. EL. 18.3 FT. NGVD AREAS "B, C + D"
MOD. BY MIN. EL. 16.5 FT. NGVD AREAS "B, C + D"
(ADOPTED)
EL. 12
MOD. BY MIN. EL. 15.0 FT. NGVD AREAS "B, C + D"
ZONE 2 (7B) EXISTING INTERIOR
STILLWATER TIDE BOSTON
EL. 8.0
START OF DAMAGE
INTERIOR R.F. DRAINAGE W/20 CFS PUMP
POINT OF PINES REVERE
ADOPTED FREQUENCY CURVES
6/84
PERCENT CHANCE OF OCCURRENCE ANNUALLY

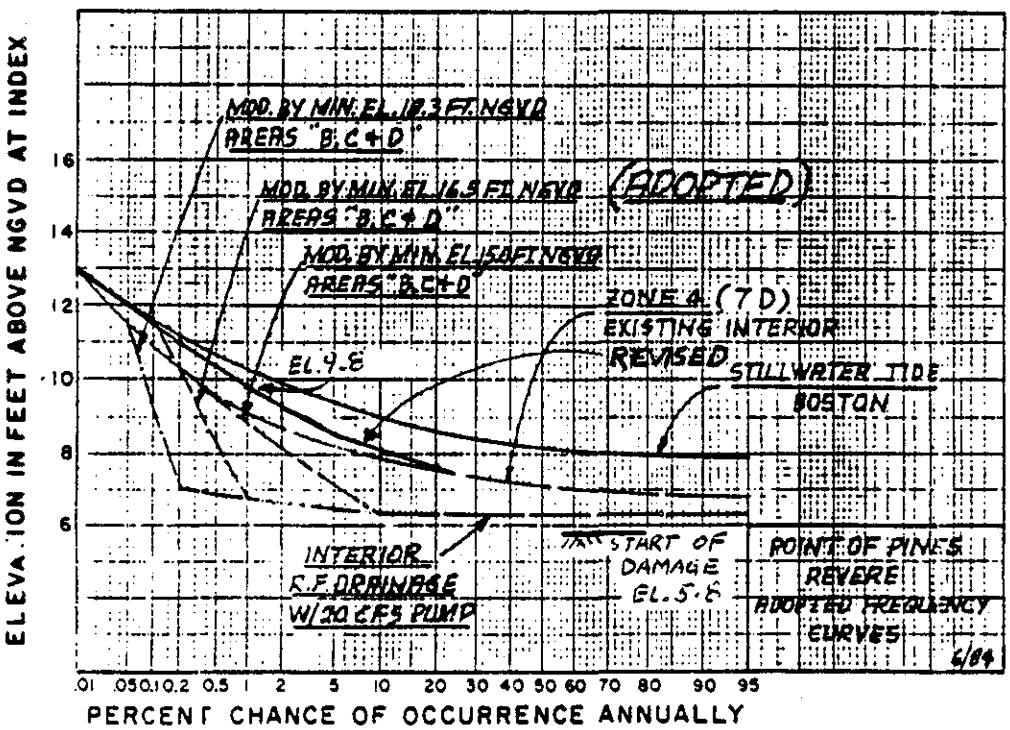

ELEVATION IN FEET ABOVE NGVD AT INDEX
MOD. BY MIN. EL. 18.3 FT. NGVD AREAS "B, C + D"
MOD. BY MIN. EL. 16.5 FT. NGVD AREAS "B, C + D"
(ADOPTED)
MOD. BY MIN. EL. 15.0 FT. NGVD AREAS "B, C + D"
ZONE 4 (7D) EXISTING INTERIOR
REVISED
EL. 9.8
STILLWATER TIDE BOSTON
INTERIOR R.F. DRAINAGE W/20 CFS PUMP
START OF DAMAGE EL. 5.8
POINT OF PINES REVERE
ADOPTED FREQUENCY CURVES
6/84
PERCENT CHANCE OF OCCURRENCE ANNUALLY

FIGURE SF-16

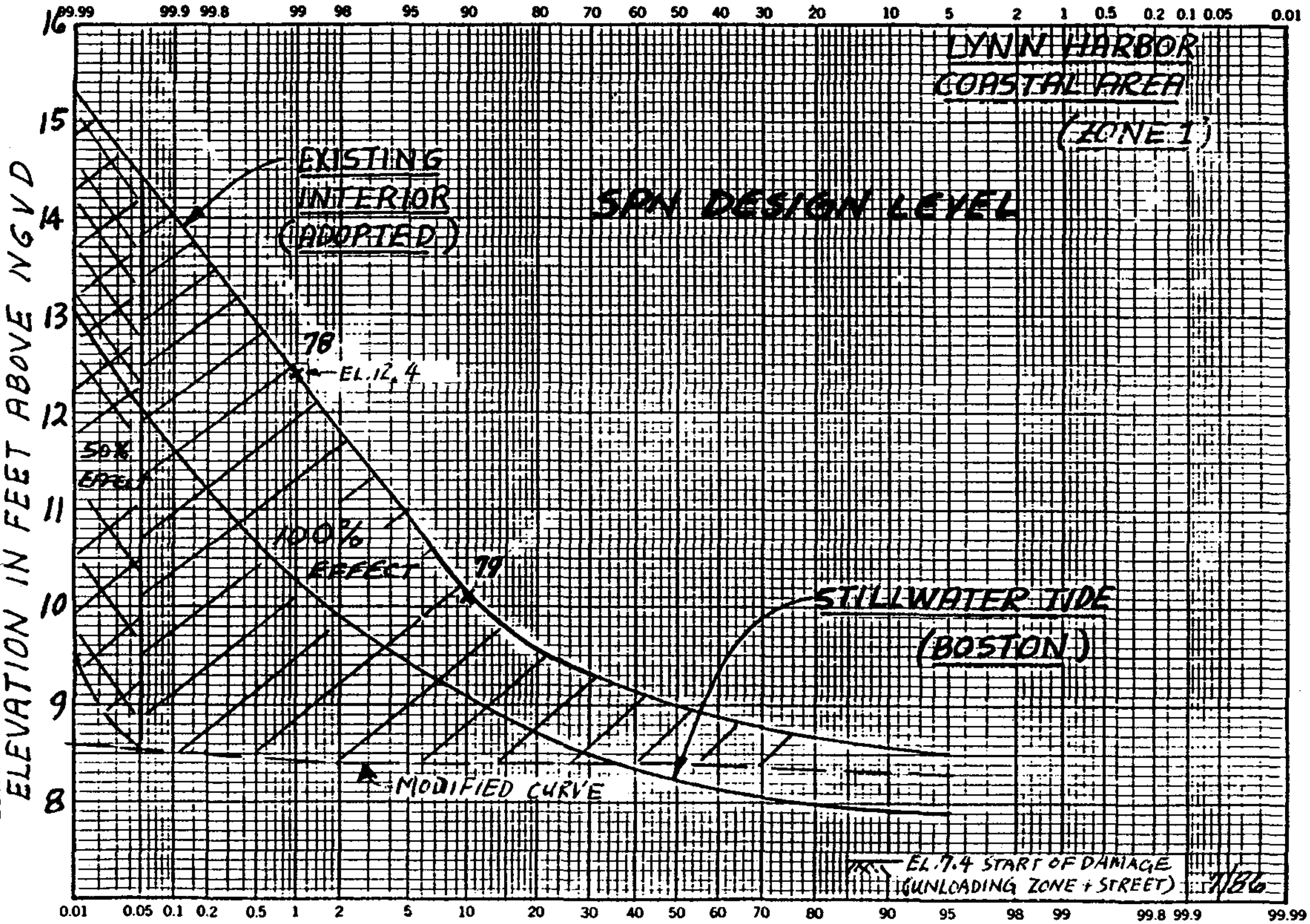

LYNN HARBOR
COASTAL AREA
(ZONE 1)
SPN DESIGN LEVEL
EXISTING
INTERIOR
(ADOPTED)
78
EL.12.4
50%
EFFECT
100%
EFFECT
79
STILLWATER TIDE
(BOSTON)
MODIFIED CURVE
EL.7.4 START OF DAMAGE
(UNLOADING ZONE + STREET)
7/86
ELEVATION IN FEET ABOVE NGVD

FIGURE SF-17

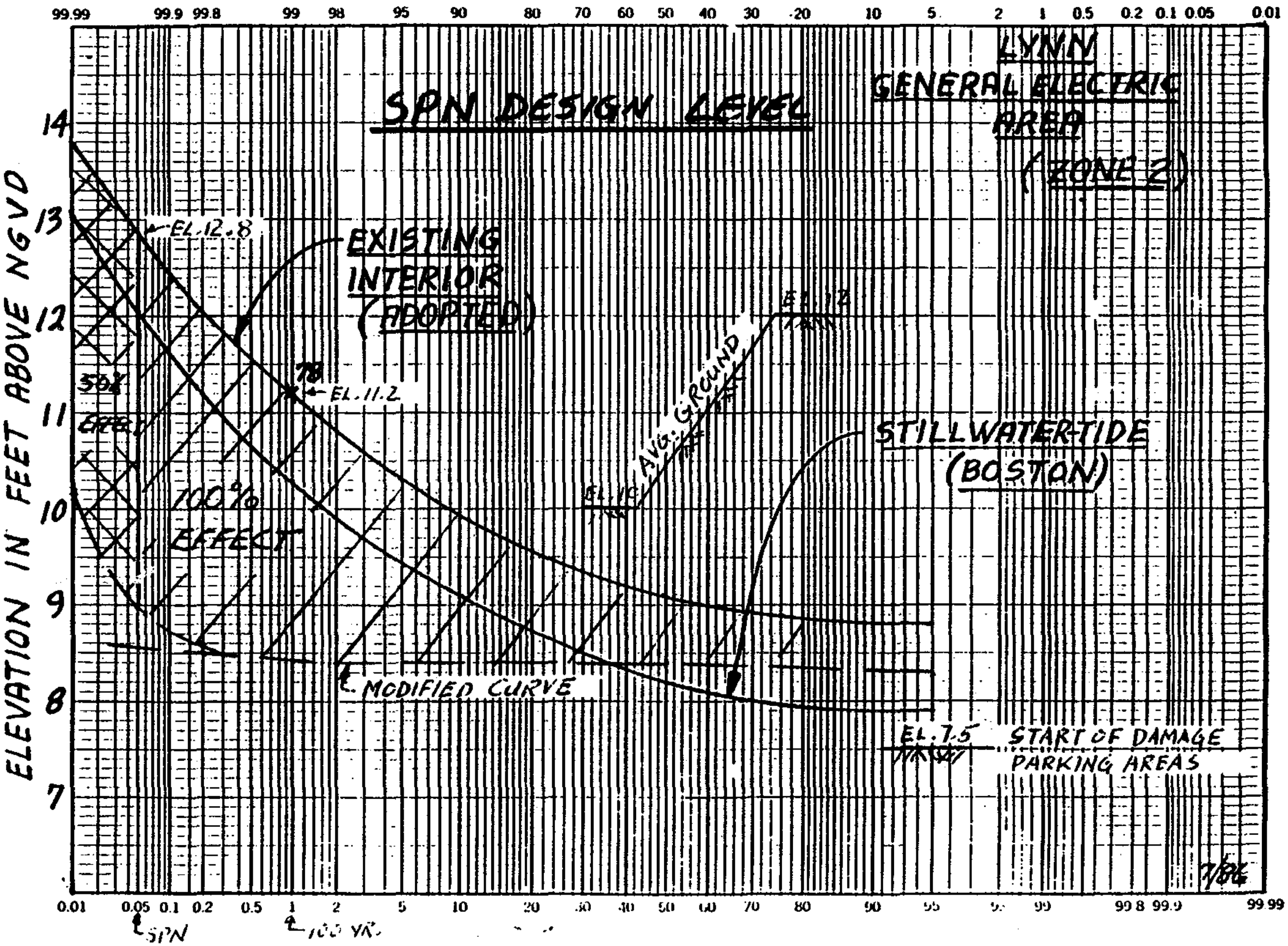
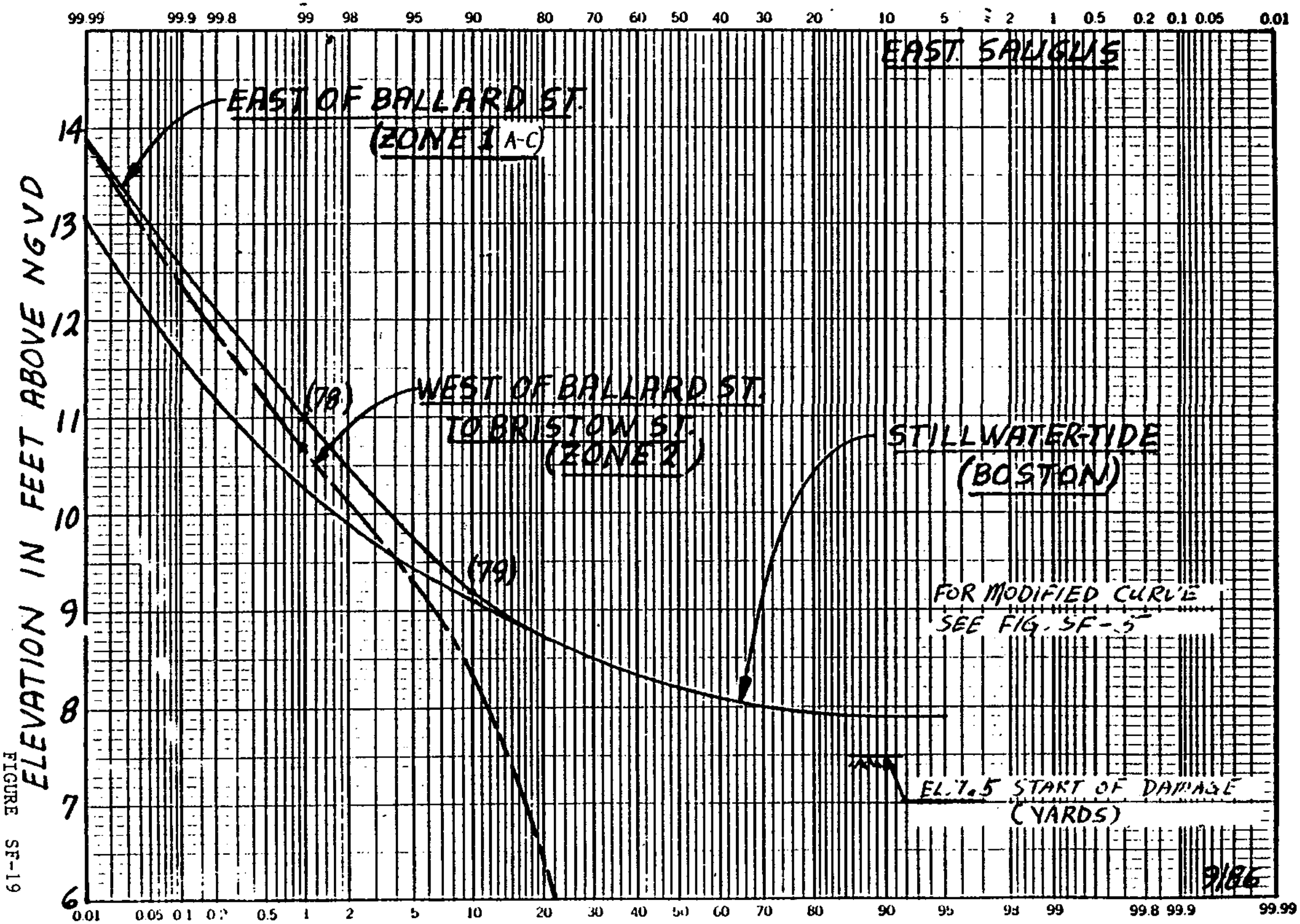

SPN DESIGN LEVEL
LYNN
GENERAL ELECTRIC
AREA
(ZONE 2)
ELEVATION IN FEET ABOVE NGVD
EL.12.8
EXISTING
INTERIOR
(ADOPTED)
EL.11.2
50%
EFFECT
100%
EFFECT
AVG. GROUND
EL.10
EL.12
STILLWATER TIDE
(BOSTON)
MODIFIED CURVE
EL.7.5
START OF DAMAGE
PARKING AREAS
SPN
100 YR.
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
14 13 12 11 10 9 8 7

FIGURE SF-18



EAST SAUGUS
EAST OF BALLARD ST.
(ZONE 1 A-C)
WEST OF BALLARD ST.
TO BRISTOW ST.
(ZONE 2)
STILLWATER TIDE
(BOSTON)
(78)
(79)
FOR MODIFIED CURVE
SEE FIG. SF-5
EL. 7.5 START OF DAMAGE
(YARDS)
ELEVATION IN FEET ABOVE NGVD
9/86

FIGURE SF-19

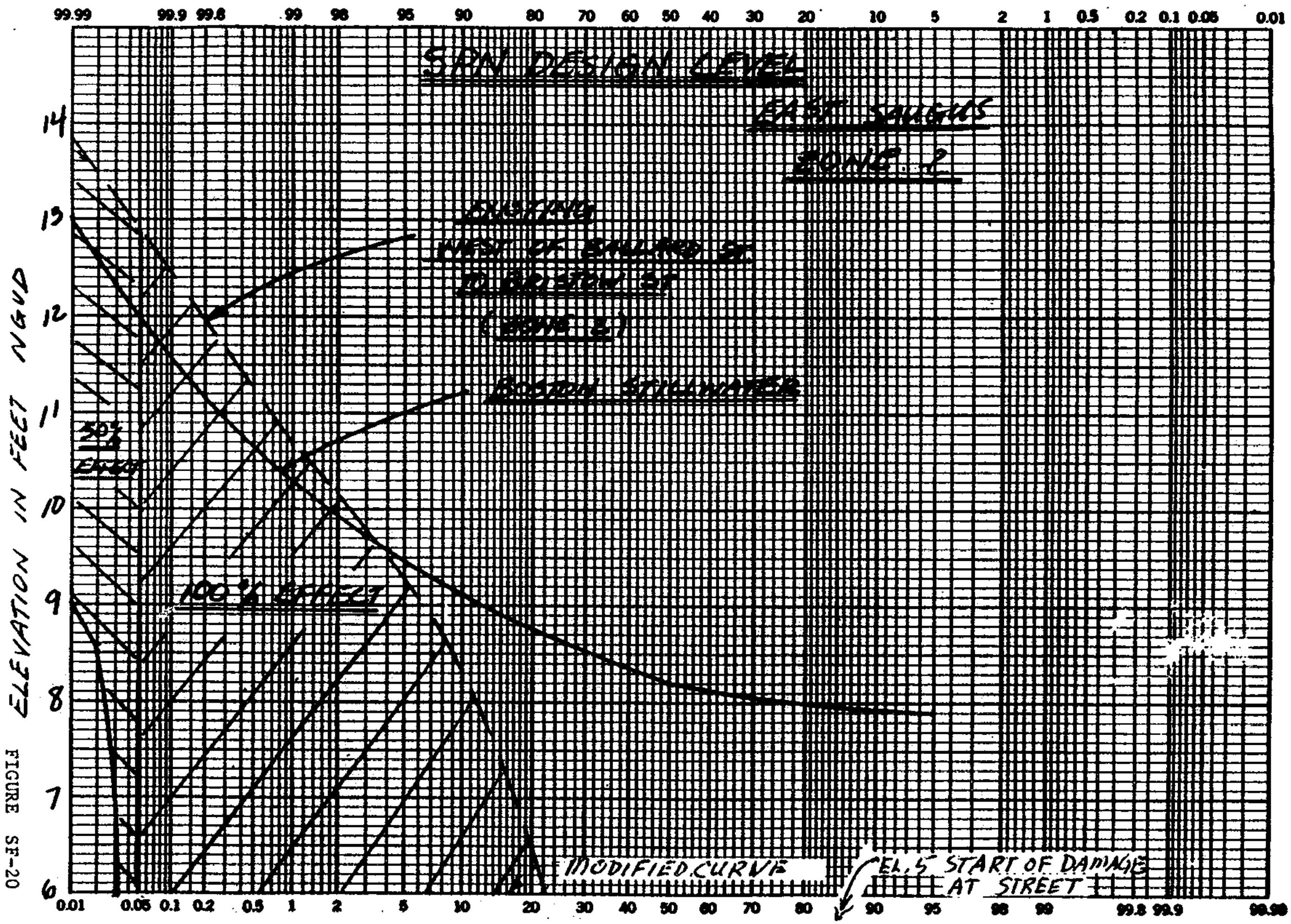

SPN DESIGN LEVEL
EAST SAUGUS
ZONE 2
EXISTING
WEST OF BALLARD ST
TO BRISTOW ST
(ZONE 2)
BOSTON STILLWATER
50%
100% EFFECT
MODIFIED CURVE
EL. 5' START OF DAMAGE
AT STREET
ELEVATION IN FEET NGVD
6
7
8
9
10
11
12
13
14
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

FIGURE SF-20

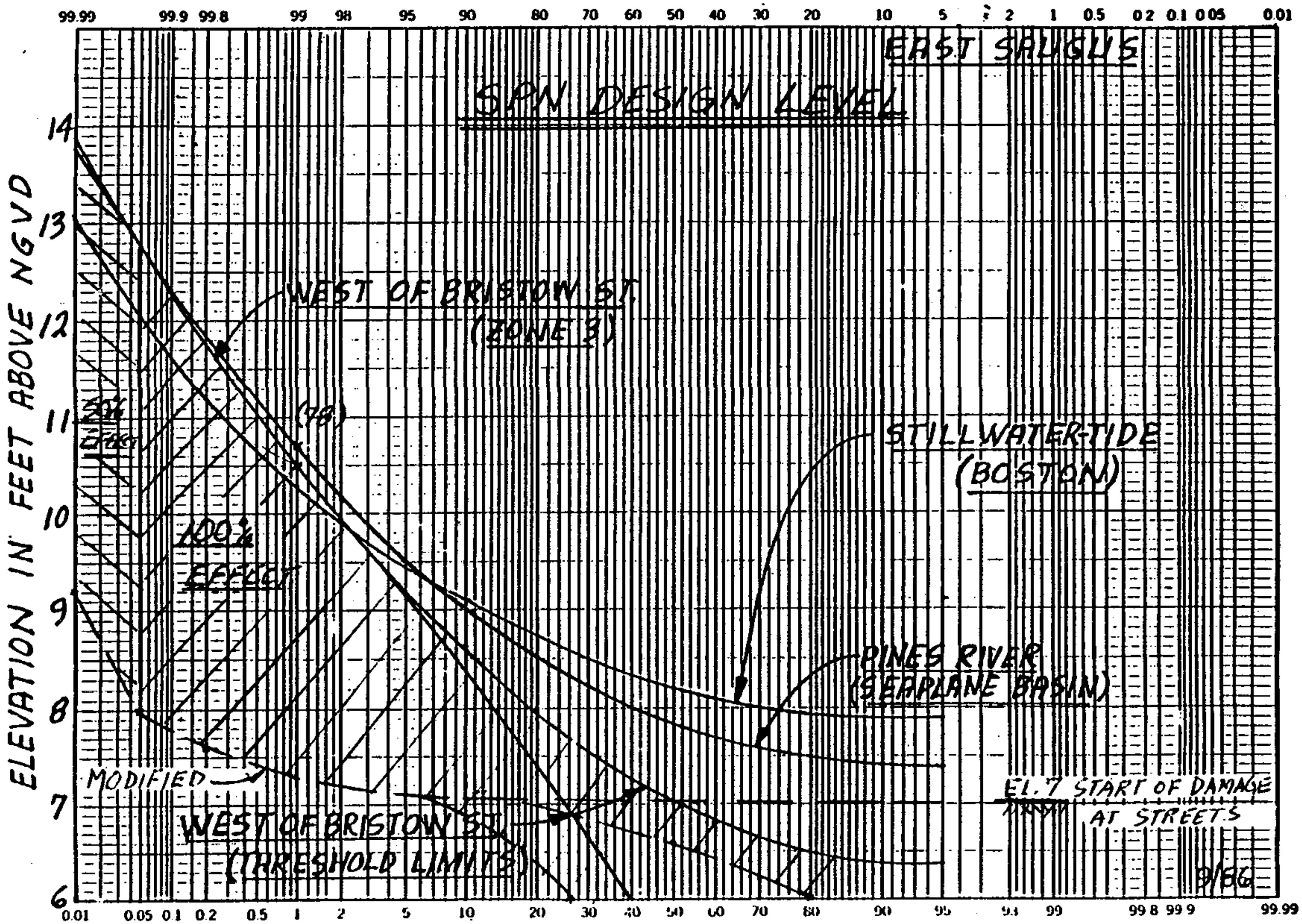

EAST SAUGUS
SPN DESIGN LEVEL
WEST OF BRISTOW ST.
(ZONE 3)
STILLWATER-TIDE
(BOSTON)
PINES RIVER
(SEAPLANE BASIN)
100%
EFFECT
MODIFIED
WEST OF BRISTOW ST.
(THRESHOLD LIMITS)
EL. 7 START OF DAMAGE
AT STREETS
ELEVATION IN FEET ABOVE NGVD
9/86

FIGURE SF-21

ADDENDUM 5

NONSTRUCTURAL
METHODS

GENERAL NONSTRUCTURAL METHODS

TABLE OF CONTENTS

GENERAL NONSTRUCTURAL CONSIDERATIONS

FLOODPROOFING MEASURES

Floodproofing, by definition, is a body of techniques for preventing damages due to floods, requiring adjustments both to structures and to building contents, and it involves keeping water out as well as reducing the effects of water entry. Such adjustments can be applied by the individual or as part of a collective action either when buildings are under construction or during remodeling or expansion of existing structures. They may be permanent or temporary.

Floodproofing, like other methods of preventing flood damages, has its limitations. It can generate a false sense of security and discourage the development of needed flood control and other actions. Indiscriminately used, it can tend to increase the unwise use of flood plains resulting from unregulated floodplain development.

A floodproofing program would normally warrant serious consideration in the following circumstances:

- Where floodproofing is the most economically feasible solution;
- Where flood control projects are not feasible due to environmental, social or economic reasons;
- Where reduced flood risk could lead to more favorable flood insurance rates; and
- Where existing flood control projects provide only partial flood protection.

Floodproofing measures can be classified into three broad categories. First, there are permanent measures which become an integral part of the structure or land surrounding it. Second, there are temporary or standby measures which are used only during floods, but which are constructed and made ready prior to any flood threat. Third, there are emergency measures which are carried out during flood situations in accordance with a predetermined plan.

Only the first two types of measures will be discussed in the following sections, which will focus on their use in existing structures located in flood hazard areas.

In recent years, floodproofing measures have generally come to be known as "nonstructural" to distinguish them from so called "structural" measures, traditionally associated with major flood control works. The two names are used interchangeably in the presentation of individual types of measures that follow. Although numerous measures exist, depending upon the degree of protection to be provided, the following nonstructural measures are discussed in detail:

- Installation of temporary or permanent closures for openings in existing structures.

- Raising of existing structures in place.

- Rearrangement or protection of damageable property within an existing structure.

- Relocation of existing structures from a flood hazard area.

a. <u>Temporary and Permanent Closures For Openings in Existing Structures</u>

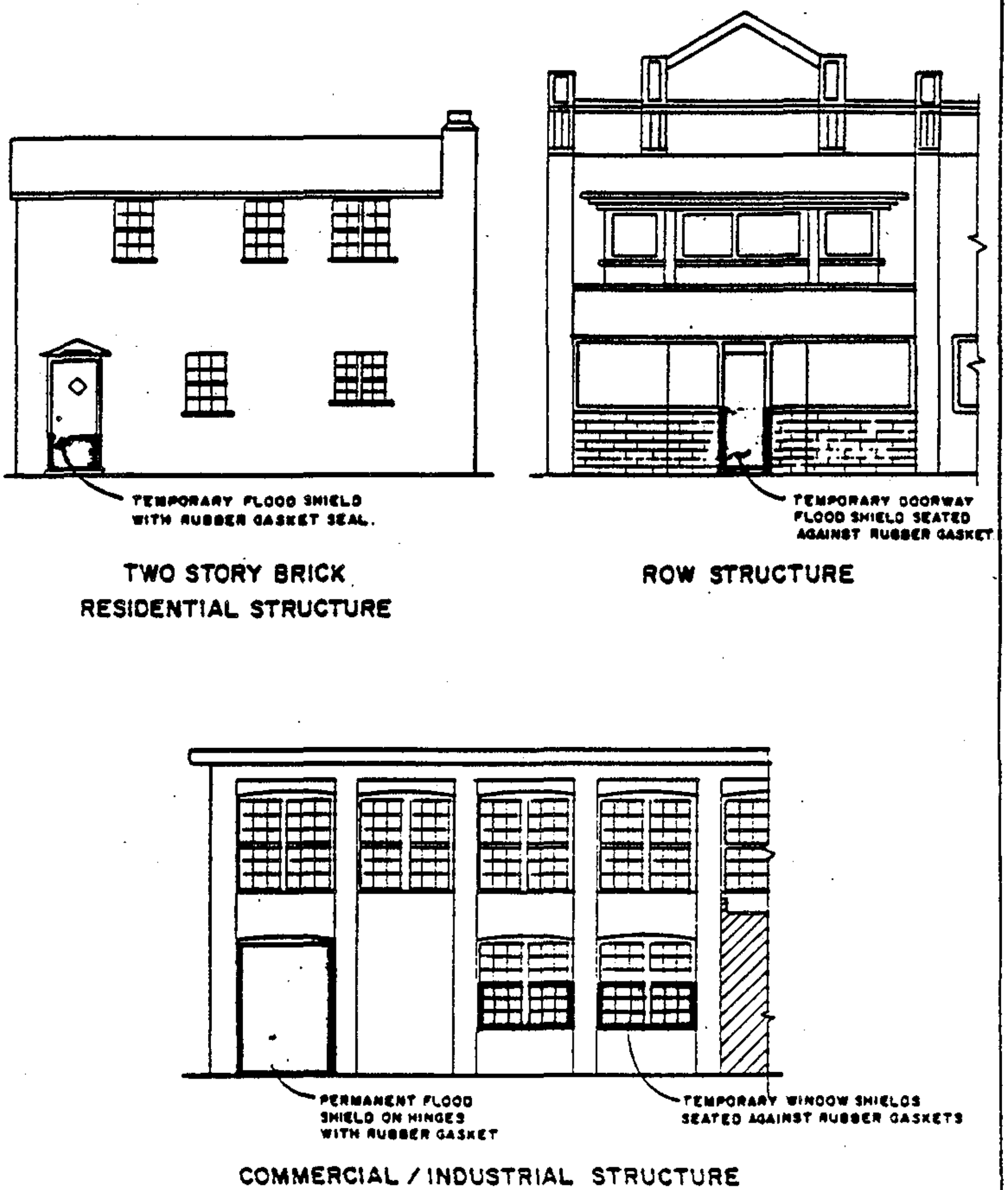
Structures whose exteriors are generally impermeable to water can be designed to keep floodwaters out by installing watertight closures to openings such as doorways and windows as shown on Figure D-1. While some seepage will probably always occur, it can be reduced by applying sealants to walls and floors and providing floor drains where practical. Closures may be temporary or permanent. Temporary closures are installed only during a flood threat and therefore need warning time before installation. Specific measures which may be undertaken are described below.

Doorway Closures - To prevent seepage around exterior doors, installation of some form of floodproofing is required. One of these is flood shields. Shields are normally fabricated of aluminum steel, or wood and made to the height and width desired. In commercial/industrial structures they may be permanently installed on hinges or rollers for swinging or sliding into place or, more often and particularly for residential structures, they may be stored nearby for installation during a time of flood. Doorways not needed may be permanently closed in with masonry or other relatively impermeable materials.

Window Closures - Normal window glass will take little hydrostatic pressure and is especially vulnerable to breakage by floating debris. Flood shields are commonly used to protect windows and prevent water from entering the structure. They may be permanently installed on hinges or rollers at the window opening or stored elsewhere and installed temporarily during floods. Windows not needed can be permanently closed in with masonry or other impermeable materials.

Floodproofing measures such as waterproofing sealants are sometimes applied to generally impermeable floors and walls to further reduce seepage. Sewer lines and other plumbing facilities can be floodproofed by installing backflow valves, gate valves and floor drains equipped with backflow prevention features.

Some seepage is likely to enter a structure even though it is made generally watertight so sump pumps should be available to remove seepage that might occur. The pump discharge should be installed above the expected level of flooding.



Temporary and Permanent Closures

FIGURE D-1

The above measures are those generally used to keep water out of a structure. They can be used in any combination depending on specific site conditions.

Physical Feasibility. Most structures, whether residential, commercial or industrial, are not designed to withstand hydrostatic pressure on the exterior walls. Therefore, when discussing physical feasibility the principal considerations are that (1 the exterior walls are impermeable or can be made so, (2) all openings below the design level can be closed, and (3) the structure can withstand anticipated hydrostatic pressures including buoyancy.

Structures with exterior walls constructed of masonry materials are relatively impermeable and can be made more so by sealing exterior surfaces. Such structures are particularly suited to keeping out water and the only adjustments necessary are to minimize seepage through walls and floors with waterproofing materials and closing of doorways, windows and plumbing lines. Structures with sidings of generally permeable materials are difficult to floodproof to the extent of keeping water out. Even for structures constructed of relatively impermeable materials, the condition of the structure and the number, location, and size of opening influence the feasibility of providing closures.

When water is prevented from entering a structure the walls become subject to lateral and hydrostatic forces which may cause buckling or flotation. Most structures are not designed to carry these forces and consequently are in danger of collapse or floating if floodwaters rise too high. It is particularly difficult to analyze the capability of existing structures to resist these forces because of the general lack of knowledge about workmanship and materials used during construction and about the present condition of these materials.

Advantages

. Floodproofing may be done on a selective basis to only those openings through which water enters and only to the height desired.

. Easy and quick to implement.

. For large commercial and industrial type structures, this may be the most important nonstructural means of flood damage reduction.

Disadvantages

. Applicable only to structure with brick or masonry type walls and without basement, which can structurally withstand the hydrostatic and uplift pressure of the design flood and which are generally watertight.

. Reduced likelihood of effective closure at nights and during vacations with temporary closures.

. May create a false sense of security and induce people to stay in the structure longer than they should.

b. Raising Existing Structures

Existing structures in flood hazard areas can often be raised in place to a higher elevation to reduce the susceptibility of the structures to flood damage as shown on Figure D-2.

Physical Feasibility. Technology exists to raise almost any structure. From a practical viewpoint, raising-in-place is most applicable to structures which can be raised by low-cost conventional means. Generally, this means structures that (1) are accessible below the first-floor level, (2) are light enough to be raised with conventional house-moving equipment, and (3) do not need to be partitioned prior to raising. Wood-frame residential and light commercial structures with first floors above grade are particularly suited for raising.

Structures with concrete floor slabs (slab-on-grade) and structures with common walls are not feasible to raise without special equipment involving additional expense.

Advantages

. Damage to structure and contents is reduced for floods below the raised first floor elevation.

. Particularly applicable to single and two-story frame structures on raised foundations.

. Structures have been raised to heights up to nine feet. The greater heights are probably most acceptable in wooded areas of steep topography.

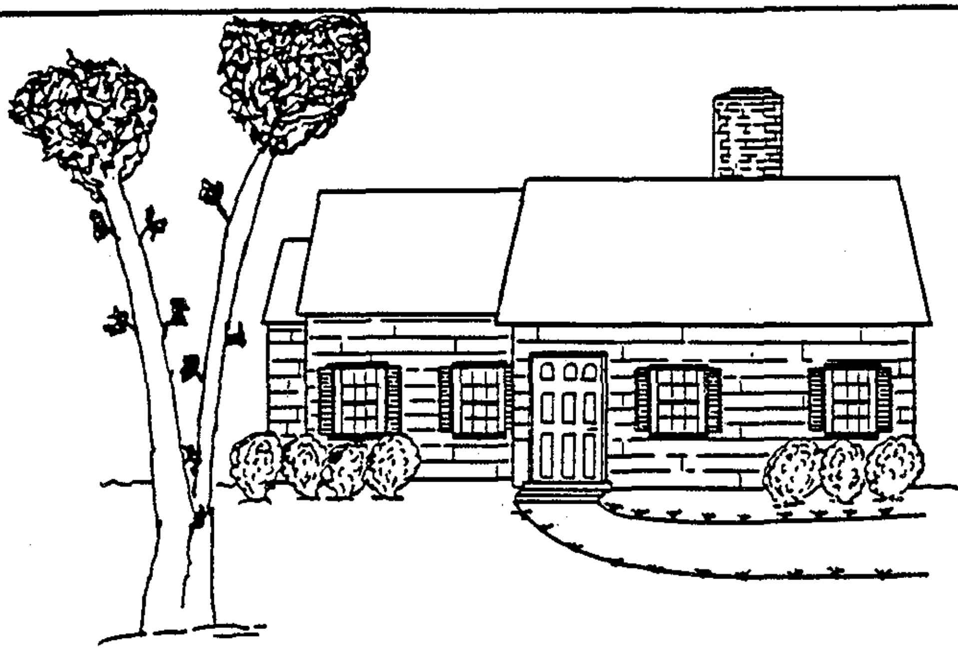
. The means of raising a structure are well known and contractors are readily available.

. Raising in-place allows the owner/user to continue living/working at the existing location.

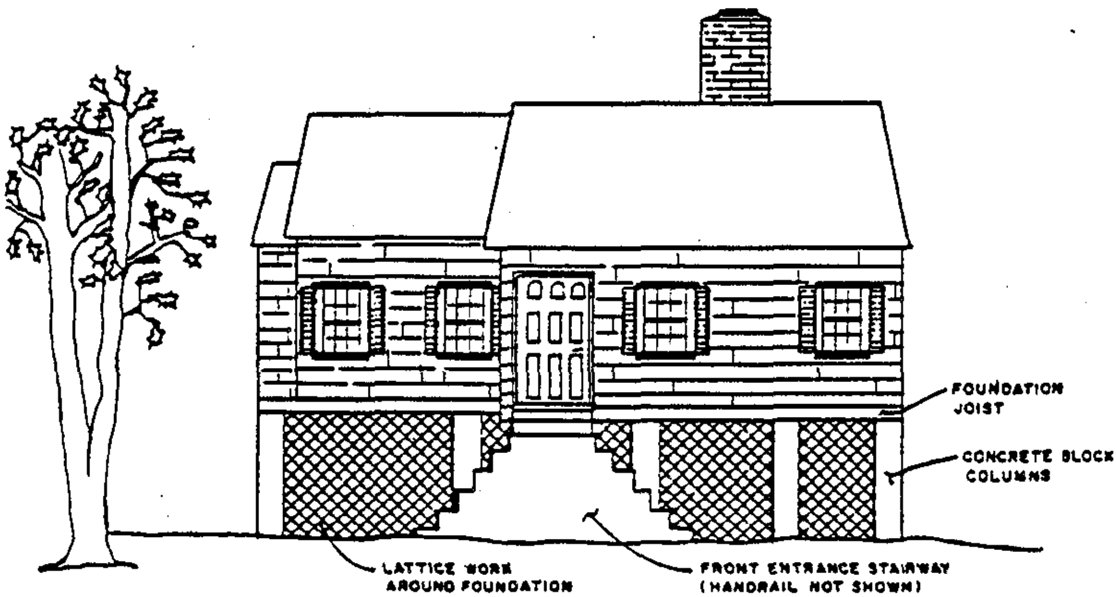
Disadvantages

. Residual damages exist when floods exceed the raised first floor elevation. Minor damage may occur below the first floor depending upon use.

. Not generally feasible for structures with slab-on-grade foundations or structures with basements (unless basement flooding is tolerated).



RESIDENCE BEFORE RAISING



RESIDENCE AFTER RAISING

Raising Existing Structure

FIGURE D-2

. Landscaping and terracing may be necessary if the height raised is extensive.

c. Rearranging or Protecting Damageable Property Within an Existing Structure

Within an existing structure or group of structures damageable property can often be placed in a less damageable location or protected in-place. It is something every property owner can do to one degree or another, depending upon the type and location of damageable property and upon the severity of the flood hazard as shown in Figure D-3.

Examples of this type of action are described as follows:

. Protecting furnaces and appliances by raising them off the floor. This may be appropriate for shallow flooding conditions.

. Relocating damageable property to higher floors.

. Relocating commercial and industrial finished products, merchandise and equipment to a higher floor or adjacent and higher buildings.

. Relocating finished products, materials, equipment and other moveable items located outside a structure to an adjacent, less floodprone site.

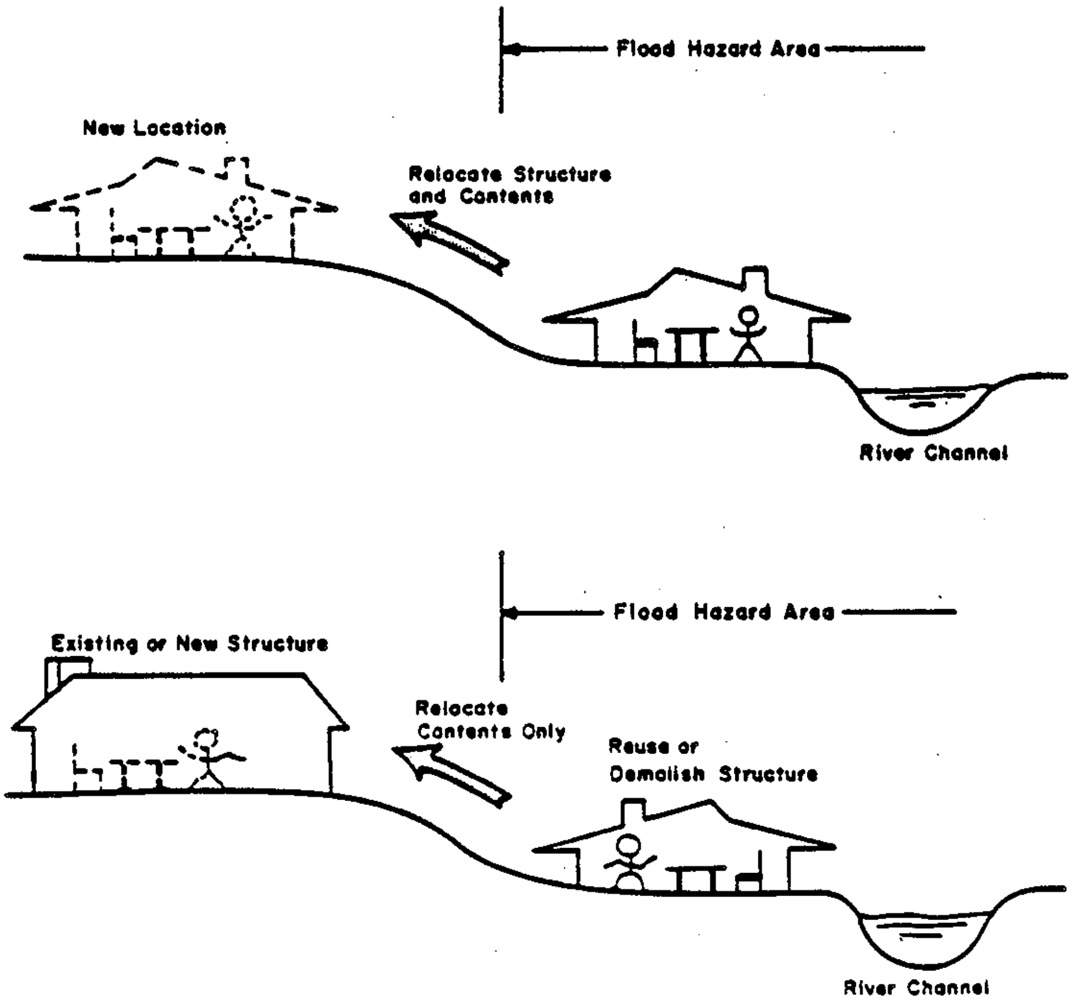
. Protecting commercial/industrial equipment by placing them on a pedestal, table or platform.

. Anchoring all property which might be damaged by movement from floodwaters.

. Protecting important mechanical and electrical equipment by inclosing them in a watertight utility cell or utility room.

Physical Feasibility. The degree to which property can be rearranged and protected is site specific. It depends on the flood hazard, principally depth and frequency of flooding; upon the damageable property, its type, value, location and moveability; upon the availability and adaptability of adjacent, less flood-prone locations; and upon whether the rearrangement can be maintained over a succession of flood-free years. Shallow flooding allows the use of protective types of measures where appliances, utilities, equipment and goods can be raised in-place and protected. Where the hazard is more severe and inundation is to greater depths, property will need to be relocated to prevent damage.

Residual damage to both structure and contents will remain even when property is rearranged or protected. For these reasons, protection of property seems to be given most serious consideration when other measures are either not physically or economically feasible or the depth of flooding is relatively shallow.



Removal of Existing Structure and/or Contents

FIGURE D-3

Advantages

. Most any residential, commercial or industrial property owner can do this to one degree or another.

. It can be done on a per item basis thus reducing the cost and allowing selective protection of high value contents.

. A structure can continue to be used at its existing site.

Disadvantages

Damage can be reduced only on those items which can be relocated or protected.

. A potential residual damage to the structure and contents not relocated or protected remains.

. New patterns must be established for relocated property.

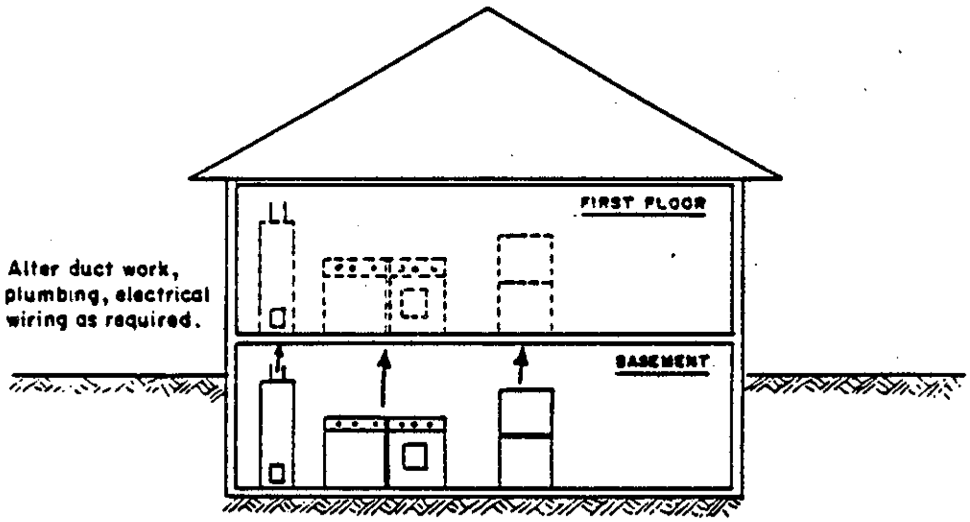
d. <u>Relocation of Existing Structures and/or Contents From a Hazard Area</u>

There are basically two options for removing property to a location outside the flood hazard area. One option is to remove both structure and contents to a flood-free site; the second is to remove only the contents to a structure located out of the flood hazard area and demolish or reuse the structure at the existing site within the flood plain. Each of these options is shown in Figure D-4.

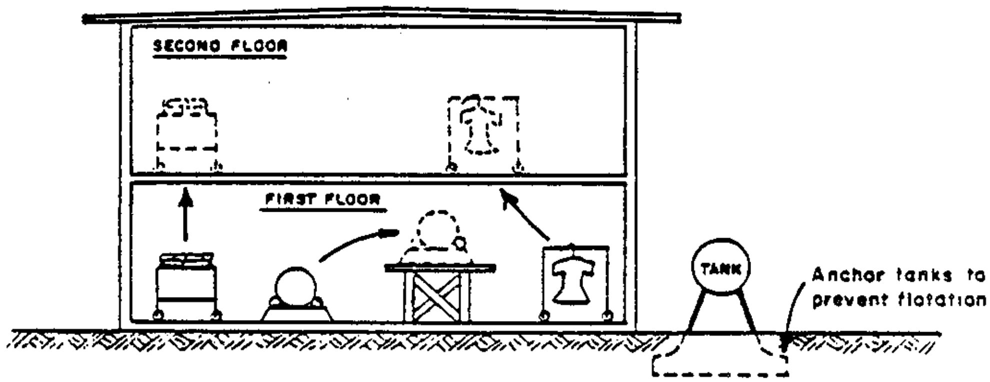
If the structure is reused, it should be for something with contents that are not readily damageable. Preserving a structure for historic purposes is one example. There are also other possibilities such as removing part of the contents, relocating one of a group of structures, or modifying an existing structure to accommodate a new use. In each case the purpose is to remove damageable property from the hazard area, yet take advantage of opportunities for using the existing property in ways which are compatible with the hazard.

<u>Physical Feasibility</u>. While the experience and equipment exist for moving many different types of structures, there is a practical limit on the size and type of structure that is economically feasible to move to reduce flood losses. Even the most readily relocatable structures are costly to remove.

One or two-story residential and light commercial structures of wood frame on raised foundations or basements are usually easy to move because of the structure weight and access to the first floor joists. Structures of brick, concrete or masonry can also be moved; however, additional precautions must be taken to prevent excessive cracking. Most commercial/industrial buildings are not feasible to move because of their



Raise Furnace, Water Heater, Washer, Dryer to First Floor



Raise and Relocate Merchandise and Equipment, Anchor Floatable Items.

Rearranging or Protecting Existing Property size and type of construction. Rather than relocate the structure, it is usually more practical to remove the contents and find a new use for it. Similar action is sometimes taken when the damage potential to contents is high, as with valuable merchandise or machinery. In such cases, if the contents cannot be protected in some other way they are often relocated out of the flood hazard area altogether.

The advantages of removing existing contents from a flood hazard area are listed below:

Advantages

. Flood damage to the existing contents is eliminated. If the structure is demolished potential structural damage is eliminated.

Disadvantages

. Damage to the structure and site remain if the structure is reused.

. Costs to remove contents and demolish the structure are high compared to other measures.

The advantages and disadvantages of removing existing structure and contents from a flood hazard area are listed below:

Advantages

. Flood damage is eliminated because there is no residual damage.

. Removal allows land use adjustments that may be beneficial to the community.

. Improved hydraulic performance for passing flood flows.

. Maintenance of flood plain land may be reduced.

Disadvantages

. Compared with other measures for existing structures, removal is costly.

. Advantages associated with being at the flood plain site are lost.

. The vacated site requires continued maintenance with associated costs.

e. <u>Summary of Floodproofing Measures</u>

Floodproofing, as part of the entire spectrum of nonstructural flood damage reduction measures, has important value when considered as part of a broader program for comprehensive flood plain management. Continued occupance of developed floodplain sites, and even new development of such sites, may become necessary in some low-lying places, especially in certain urban areas where a shortage of land may offer no realistic alternative. The nonstructural measures for flood damage reduction have an important role alongside traditional structural measures usually associated with major flood control projects.

However, the foregoing general conclusion should not be misunderstood or misinterpreted. Nonstructural measures, like structural measures, have their particular applications and limitations. Each measure must be evaluated for its specific application in the reduction of flood damages and only then can it be decided that the particular measure is feasible, physically and economically.

Some measures could be used exclusively for existing development, others for future; some for residential structures, and others for commercial/industrial buildings; some at locations of frequent flooding, others where it is less frequent.

Lastly, floodproofing and the nonstructural approach to flood loss reduction are not cures for all flood problems. They can increase interest in flood damage reduction programs by heightening public awareness of the flood risk.

FLOOD FORECAST, WARNING AND EVACUATION

Flood forecast, warning and evacuation is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.
- Procedures for issuance and dissemination of a flood warning.
- Arrangements for temporary evacuation of people and property.
- Provisions for installation of temporary protective measures.
- A means to maintain vital services.
- A plan for postflood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process will communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday, weekend) and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain credibility of future warnings.

An effective warning needs to be followed by an effective response. This means prompt and orderly evacuation of people and property. Actions which can facilitate this include:

. Establish of rescue, medical and fire squads.

. Identification of rescue and emergency equipment that can be utilized during a flood.

. Identification of priorities for evacuation.

. Surveillance of evacuation to insure safety and protect property.

In addition to evacuation, property can be protected by various measures, temporary flood proofing of structures, use of pumps and flood fighting. For instance flood fighting includes such actions as raising the level of existing protection; closing highways, streets and railroads; preventing backwater in sewers; and protecting against erosion. All of these actions contribute to the overall goal of reducing flood loss.

In addition, a forecast, warning and evacuation strategy will include telephone, energy (gas and electric), sewage, water, traffic control and hospitals as well as police and fire services. Postflood reoccupation and recovery includes:

. Reestablishment of conditions that will not endanger public health: disease and insect control, safe drinking water, safe sewage disposal, medical supplies.

. Return of other vital services.

. Removal of sediment, debris, flood fighting equipment and materials.

. Repair of damaged structures.

. Establishment of disaster assistance centers for financial and other assistance.

Factors that determine the physical feasibility of forecast, warning and evacuation measures are somewhat different from those which determine the physical feasibility of many other nonstructural measures, whose feasibility is directly related to the type of structure and depth of flooding. Forecast, warning and evacuation feasibility is more dependent upon hydrologic, social and instritutional factors. The selection and feasibility of forecasting capability depends upon the size of the drainage area, whether the river is a main stem or tributary, travel time, and other hydrologic factors that influence the reliability of forecasts. Small watersheds generally have short response times, making it especially difficult for warnings to be helpful. The feasibility of warning systems also depends upon social factors. One system may be appropriate for one community, but not for another because an infrastructure of community and institutional arrangements is necessary to effectively use hydrologic information. The degree to which this infrastructure is created influences the effectiveness of different warning and evacuation measures.

Advantages

. Preparedness planning is almost always economically feasible and desireable. Something can usually be done even in areas where other flood loss reduction measures are implemented.

. A significant saving of lives may result in flash flood or water related structural failure situations.

. Accurate forecasts and warnings may permit sufficient time to implement temporary protective measures to significantly reduce flood damage.

Disadvantages

. The effectiveness of the warning system and response of the community cannot be accurately predetermined, consequently neither can potential flood damage reduction.

. Requires a continuous awareness and information program, maintenance of equipment, etc.

. Effectiveness of preparedness plans tends to diminish with increasing time between floods.

FLOODPLAIN REGULATIONS

Through proper land use regulation, floodplains can be managed to insure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building and housing codes. Their purpose is to reduce losses by controlling the future use and changing the existing use of floodplain lands.

Some regulations covering the use of the floodplains are already in effect in the communities within the study area. Regulations may be relatively prohibitive or may allow construction, provided the new structures are floodproofed and/or elevated above a designated flood elevation.

Physical Feasibility. Zoning ordinances, subdivision regulations, and building and housing codes are generally feasible for any floodplain land, whether the land is occupied by residential, commercial or industrial structures, or by nonstructures such as golf courses and playgrounds. While there are no general limitations, a regulatory program is developed and administered for a specific piece of land in a specific community and State; thus, when developing such regulations at the local level some very real restrictions may develop.

Regulations must be flexible and fair. Procedures for amendments and variances are necessary and can be provided by establishing criteria for special use permits. Also, regulations must be designed to prevent public harm rather than serve public benefits.

Advantages

. An effective means of bringing about the proper use of floodplain lands. Economic, environmental, and social values can be integrated with the recognized flood hazard.

. Helps to keep flood damage from increasing. By addressing nonconforming uses they can be helpful in achieving the necessary land use adjustments to mitigate existing flood problems.

. Can be effective over time on existing improper development or additions and modifications to existing property.

Disadvantages

. Not effective in reducing flood damage to existing structures.

. Subject to variance or amendment by local governmental bodies which can reduce effectiveness considerably.

. Tend to treat all floodplain property equally when in fact various economic factors may make one type of development more appropriate for one portion of the floodplain and another type more appropriate elsewhere.

FLOOD INSURANCE

Flood insurance is not really a flood damage prevention measure as it doesn't reduce damages, rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners. Prior to this program, the response to flood disasters was limited to the building of flood control works and providing disaster relief to flood victims. Insurance companies would not sell flood coverage to property owners, and new construction often overlooked new flood protection techniques. The insurance program, however, did not come about overnight; it took several attempts and 17 years before the bill was approved and put into effect.

Flood insurance compensates purchasers for losses to the dwelling or business they own and to the contents of these buildings. Flood insurance is an option for all owners of existing buildings in a community approved for the sale of flood insurance, yet it is compulsory for all buyers of existing or new buildings in the Federal Emergency Management Agency (FEMA) designated 100-year floodplain where Federally insured mortgages or mortgages through Federally connected banks are involved.

Qualifying for the National Flood Insurance Program involves a community in two separate phases -- the emergency phase and the regular phase. The emergency phase limits the amount of insurance available to local property owners. In this phase, FEMA provides the community with a Flood Hazard Boundary Map that outlines the flood-prone areas within the community. Owners of all structures, regardless of their flood risk, are charged subsidized rates during this phase of the program.

In order to quality for the Emergency Program, a community must adopt preliminary floodplain management measures including building permits for all proposed construction or other development in the community, which must be reviewed to assure that sites are reasonably free from flooding. The community must also require that all structures in flood-prone areas be properly anchored and made of materials that will minimize flood damage, new subdivisions must have adequate drainage, and new or replacement utility systems must be located and designed to prevent flood loss.

The full amount of flood insurance is available under the regular phase of the program. The amounts charged for insurance of new construction vary in accordance with the structures. Flood plain management efforts of the community become more comprehensive and new buildings must be elevated or floodproofed above certain flood levels. The floodproofing levels are shown on a Flood Insurance Rate Map which is derived from a detailed on-site engineering survey in the community. This map also shows flood elevations and outlines risk zones for insurance purposes.

When the Flood Insurance Rate Map is completed, the community may qualify for the Regular Program by adopting more comprehensive floodplain management measures. Along with the measures adopted for the emergency program, the community must also require that all new construction or any substantial improvements to existing structures be elevated or floodproofed to the level of the base flood. All of the communities in the study area are in the Regular Program.

Advantages

- Inexpensive to the insured at the subsidized rate.
- Available to persons in many communities.
- Indemnification is for any flood up to the limits of the policy.

Disadvantages

. Only available to persons in communities eligible to participate in the Flood Insurance Program.

. Indemnification is limited both in magnitude and in type of damage.

. A deductible provision for each loss makes it somewhat less attractive for low damage flooding.

. Damages are not reduced.

PUBLIC ACQUISITION OF FLOODPLAIN LAND

Public control over the floodplain may be obtained by purchasing the title or some lesser rights to it such as development rights, right of public access, or rights to use the land in some specified way.

Acquisition of the title is most suited for the undeveloped or sparsely developed land in most of the floodplain. Given the amount of land along the Connecticut coastline this approach has practical limitations. It is a very desirable means, however, of protecting and or providing public access to particularly sensitive or significant areas for environmental, wildlife protection, public open space and recreation or other purposes. Federal and State programs may be enlisted for grant and loan assistance to offset a portion of the cost of acquiring the land. With the amount of protection now available through local flood plain regulations, a program of public land acquisition is not deemed practical at this time.

The acquisition of other interests in land may be an effective instrument to insure that it remains in low intensity uses such as agriculture, tree farms, private camping areas and the like. The means of accomplishment is usually an easement granted or sold to the public agency. Ownership, use, access and occupancy may be retained by the owner, but use is restricted by the terms of the easement. In experiences with this form of land use control it has been found, in some cases, that the purchase of development rights may be almost as expensive as acquiring the full title because the owner's options have been reduced so much. Coupled with tax incentives, however, the technique has a great deal of promise as a floodplain management method.

Costs of acquisition in fee or easement depend upon the cost per acre and number of acres needed. Both items are highly variable and must be determined on a case-by-case basis. Per unit costs can vary considerably within a community, between communities and regionally. The number of acres needed depends upon the plan--it may require a few acres or thousands of acres.

Advantages

- Provides control of land and its use with fee title.

- Provides control of certain land uses with an easement, but without the burden of fee title.

Disadvantages

- Does not reduce existing damage.

- Requires land management and maintenance by the public owner.